A CONTRIBUTION TO THE STUDY OF EPIDEMIC DIARRHŒA.

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BY

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THE honour which you have conferred upon me by electing me your President carries with it the onerous duty of delivering a Presidential Address. The Presidential Addresses of my predecessors appear to come under one of two categories, either dealing with the general politics of the Public Health Medical Service, or discussing some particular subject of which the author possesses special knowledge. I cannot hope to occupy your time profitably on the former head, and it remains for me therefore to attempt the discussion of some subject to which I have given special attention during the last year or two. In adopting the latter course, I must plead guilty, in choosing epidemic diarrhœa as my theme, to having chosen a subject which many will consider to be worn threadbare by reiterated consideration, and concerning which I will —to disarm criticism—at once state that I have no startling novelty to reveal. As a zealous and persistent student of the weekly and quarterly returns of the Registrar-General, I have been repeatedly struck with the relative immunity of certain towns from diarrhœa, and formed the intention some years ago of further investigating the matter as soon as time and comparative freedom from other work would enable me to do so. Towards the end of last year I was fortunate enough to secure the aid of Dr. W. Riach in making the numerous calculations on which the results to be hereafter given are based. Without this aid the substance of my address would have still remained in embryo.

It cannot be said that a disease which in 1897 caused 4·8 per cent. of the total deaths from all causes in England and Wales, as compared with 7·6 per cent. for the six other chief zymotic diseases, can be lightly disregarded, or cease to occupy a large share of our anxious attention. My friend Dr. Hayward has recently calculated that if diarrhœa as a cause of death during the first year of life were excluded from the death-returns, the difference in the English life-table would be as follows :

	Increase in Number of Survivors at Age 1 out of a Million at Birth.	Increase in Expectation of Life.
Males	+14,544	... +0·75 year.
Females	+12,495	... +0·67 ,,
Persons	+13,540	... +0·71 ,,

1

The further results obtained by Dr. Hayward are so interesting that I insert them here for the purpose of comparison with diarrhœa :

Difference produced upon the Expectation of Life at Birth by excluding

	Phthisis	All Tubercular Diseases	Cancer	Enteric Fever	Scarlet Fever	Diphtheria	Measles	Whooping-cough	Diarrhœa
			At all Ages.				Under 5 years of age.		
Males ...	+2·58	+3·86	+0·39	+0·30	+0·53	+0·24	+0·68	+0·63	+0·95
Females ...	+2·57	+3·72	+0·83	+0·29	+0·57	+0·28	+0·67	+0·82	+0·87

I have hitherto spoken of diarrhœa as a disease, while obviously it is only the name of a symptom, which may be the most prominent feature in many diseases. It is necessary, therefore, *in limine*, to make good the claims of the official statistics of the General Register Office to a fair degree of credibility. The consciousness of the fact that diarrhœa is the name of a symptom, and not of a disease, has caused practitioners in recent years to certify many deaths caused by epidemic diarrhœa under the heading " Enteritis " or " Gastro-Enteritis." The amount of transference due to this fact is shown in Fig. 1.*

This figure shows that if we neglect the very high peaks caused by cholera, a large share of the improvement in the death-rate from diarrhœa is only apparent, being due to alteration in nomenclature. The vitiating effect upon the statistics of diarrhœa of the above cause has been illustrated by Dr. Louis Parkes by its influence on the age-incidence of deaths from diarrhœa and from enteritis.† Thus, in London the percentage of deaths under one year to total deaths from the same cause was in

	Diarrhœa and Cholera.	Enteritis.
1861-65	62	30
1896-97	79	68

The above disturbing influences give *primâ-facie* ground for doubting the utility of the official statistics of diarrhœa. It would, however, I think, be folly to refrain from studying these statistics. I hope to be able to show that, when utilized with due regard to their defects, they may form a satisfactory basis for valid conclusions. In the first place, the same transferences from diarrhœa to other headings are occurring in the death-returns of every large town or district ; and there are, so far as I can see, no just grounds for thinking that their action is on the whole greater in one than in another. The statistics to be hereafter given nearly all deal with populations exceeding 100,000, among which the vagaries of

* From the third edition of " Elements of Vital Statistics," page 205.

† *British Medical Journal*, May 28, 1898.

death certification by individual practitioners have only a modicum
of effect. The blessed law of averages appears to me to render
the diarrhœal death-rate of one town fairly comparable with that
of any other town *in the same year*, though obviously, in comparing
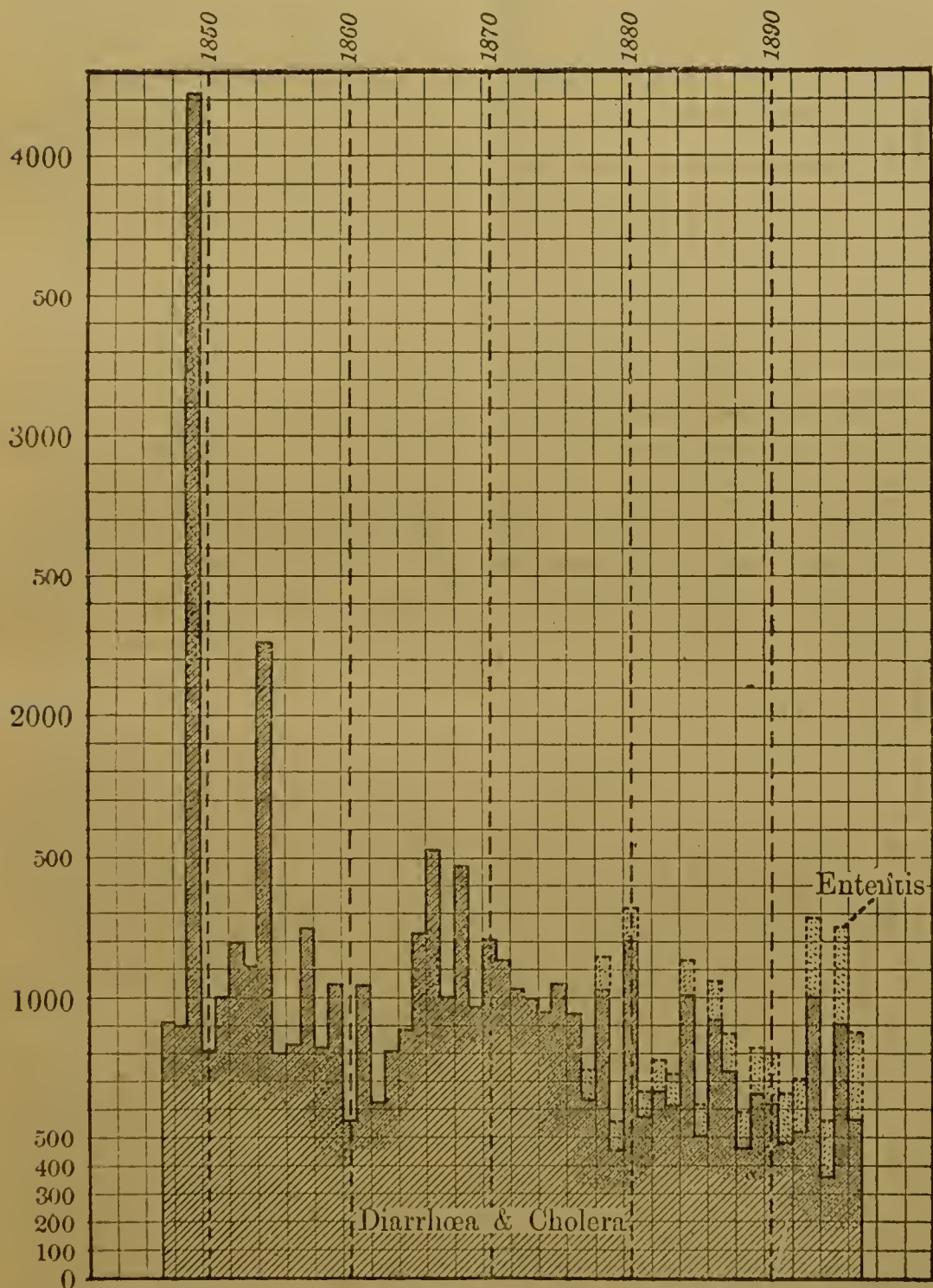diarrhœal death-rates in the present decennium with those of

Fig. 1.—Annual Death-rate per Million living 1847-96 from Diarrhœa
plus Cholera, and from Enteritis in England and Wales.

earlier years, we must allow for an unknown percentage of trans-
ference from diarrhœa to other headings. The argument on this
point is of primary importance, as, unless its validity be accepted,

1—2

the conclusions deduced in the following remarks from a comparison of the diarrhœal mortality in different towns must be regarded as possibly fallacious. I do not regard them as fallacious. I am confident that the facts for corresponding years are truly comparable.

I may remind you at this stage of the valuable paper by Dr. Ashby, and of the report of the committee appointed by the Home Counties Branch of our Society on the classification of "diarrhœa" deaths.* This committee has reported that the classification of deaths from diarrhœa "is at the present time in such a state of utter and hopeless confusion as to render the statistics of diarrhœa deaths, and consequently of zymotic death-rates, in different localities misleading, and altogether useless for comparison. Moreover it must be noted that there is not uniformity in the classification adopted by the Registrars-General in the United Kingdom. The confusion is mainly due to the unnecessarily numerous names employed by medical men to designate one and the same disease in their death-certificates."

The above remarks amply justify the important steps which have been taken to secure the consideration of this subject by a committee of the Royal College of Physicians. There is great need for uniformity of certification and classification. Fallacies due to alterations of fashion in death-certification appear to be unavoidable ; fallacies of classification only require careful instruction and co-operation for their avoidance.

It may, however, be pointed out that in the General Register Office, Somerset House, the following instructions (which I have Dr. Tatham's permission to publish) have been uniformly adopted for a long series of years in classifying diarrhœal deaths :

EXTRACT FROM INSTRUCTIONS TO REGISTRARS FOR MAKING WEEKLY RETURNS OF BIRTHS AND DEATHS.

"DIARRHŒA.—Deaths from *Intestinal* or *Enteric Catarrh* and from *Gastro-Intestinal* or *Gastro-Enteric Catarrh* should be included under this heading. Diarrhœa should, however, be counted as the cause of death, *only when stated alone, or when coupled with some ill-defined cause of death*, such as atrophy, debility, marasmus, convulsions, teething, old age, or senile decay."

The weekly and quarterly returns of the Registrar-General have thus been consistently compiled for a long series of years on a uniform system, and although this does not entirely eliminate errors caused by the occasional carelessness or lack of intelligence of local registrars, who send up these returns to the General Register Office,

* PUBLIC HEALTH, May, 1899, page 539 *et seq.*

there can, I think, be little doubt that diarrhœal death-rates for the great towns, calculated from the Registrar-General's data, are fairly comparable in each year with one another. In this respect they differ widely, as shown by the report of the committee of our Home Counties Branch, from diarrhœal death-rates compiled by local medical officers of health, without any exact rules to guide them. This point is of great importance as bearing on the accuracy of the death-rates to be shortly submitted to you.

It is obvious that the above-quoted rule for local registrars is not free from objection. It would be difficult, for instance, to justify the exclusion of " enteritis " from and the inclusion of " enteric catarrh " along with diarrhœa. But it is a rule consistently maintained, and I recommend it for the adoption of all medical officers of health until a new one is adopted. It is quite easy for the medical officer of health to have a second column in his statistical report for all deaths under other names which, in his opinion, should be included with epidemic diarrhœa ; and the gradual swelling of the figures under the latter head will furnish a useful and steady check on erroneous conclusions that might otherwise be deduced from the official figures on the Registrar-General's basis.

It is extremely difficult to see in what directions reform in the classification of diarrhœal deaths is practicable. I think it is highly desirable that we should remember the probable identity between most of the sporadic cases of diarrhœa occurring in the non-diarrhœal season and cases of epidemic diarrhœa, and not attempt to insist in every instance on the prefix "epidemic." On the other hand, it is highly desirable that deaths now certified as " gastro-enteritis " or " enteritis " should have the prefix " epidemic " when, in the opinion of the certifying practitioner, they are really deaths from the specific disease, epidemic diarrhœa.

It will be noted that I have throughout assumed the existence of a specific disease, epidemic diarrhœa—would that some acceptable name could be devised which would clearly and differentially designate it !—although in the official statistics registered deaths from this disease have an admixture of an unknown number of deaths from other diseases, and *per contra* an increasing number of deaths from epidemic diarrhœa now appear under other headings. Nor do I propose to waste time by discussing this proposition, as it will, I think, be accepted by all.

Method of Statement of Death-rate from Diarrhœa.—Having stated the limits within which the Registrar-General's figures may, if caution be exercised, be used with approximate accuracy, we come next to the method of statement of diarrhœal death-rates. About

75 per cent. of the total registered deaths from diarrhœa occur
under one year of age. In the third quarter of each year the
proportion is still higher. The Registrar-General's official method
is to state the deaths from diarrhœa in terms of the total popula-
tion. By this method towns with a large infantile population, *i.e.*,
with a high birth-rate, are unfairly handicapped in the comparison.
This is clear from the following examples taken from "Elements
of Vital Statistics" (third edition, page 188) :

Table A.

Place.	Deaths from Diarrhœa in 1896.	
	Per 1,000 of Population.	Per 1,000 Births.
Dover	·42	15·7
Hastings	·26	14·1
Percentage excess of Dover over Hastings	+61·5 per cent.	+11·4 per cent.
Huddersfield	·26	12·9
Newcastle-on-Tyne	·51	16·4
Percentage excess of Newcastle over Huddersfield	+96·1 per cent.	+27·1 per cent.

The most accurate method of all would be to state the deaths
from diarrhœa under one year of age per 1,000 births ; but statistics
for the thirty-three great English towns on this basis are not
given in the quarterly reports of the Registrar-General. Failing
this, it is clear that the statement of total deaths from diarrhœa in
terms of births, which is employed exclusively in the present inquiry,
is much more accurate than a statement of these deaths in terms of
the total population.

Through the kindness of Dr. Niven, I have been supplied with
the necessary data for the calculation of the following diarrhœal
death-rates for each township of Manchester. The letters in
brackets indicate the relative position of each township as regards
diarrhœa, when its death-rate from this disease is stated according
to each of the three methods already indicated. The table is
inserted here as an example of the relative accuracy of the three
methods mentioned above. Incidentally it throws a flood of light
on the influence of social and sanitary circumstances on the
diarrhœal death-rate.

Of the two available methods, the statement of the diarrhœal
mortality in proportion to the infantile population, being the more

Manchester Townships.	Deaths under One Year per 1,000 Births.	Deaths at all Ages per 1,000 Births.	Deaths at all Ages per 1,000 Population.	Nature of Subsoil.
I. { Ancoats	44·5 (c & d)	64·5 (b)	2·54 (a)	The portion bounded by Deansgate and the river Irwell is sand for a depth of several feet, then sandstone rock, the rest of the area being clay for a depth of 15 to 20 feet deep, then sandstone rock.
Central	53·5 (b)	69·3 (a)	2·03 (d)	
St. George's	36·1 (i)	53·3 (g)	1·89 (e & f)	
Cheetham	20·9 (p)	24·0 (p)	·83 (p)	South portion, clay ; north portion, sand ; east portion, wet sand.
Crumpsall	19·2 (q)	21·0 (q)	·42 (q)	East portion, wet sand ; west portion, sand.
Blackley	6·2 (r)	10·9 (r)	·29 (r)	North portion, sand ; south portion, wet clay ; west portion, wet sand.
Harpurhey	38·2 (g & h)	46·8 (i)	1·83 (g)	North portion, clay ; south portion, clay and some sand, also tips.
II. { Moston	25·6 (o)	32·7 (o)	1·17 (l & m)	East portion, clay ; south portion, wet sand, sand and clay.
Newton	28·7 (l)	38·2 (l)	1·17 (l & m)	Clay.
Bradford	44·5 (e & d)	62·5 (c)	2·38 (c)	Chiefly clay.
Beswick	32·3 (j)	43·3 (j)	1·58 (j)	Chiefly clay.
Clayton	53·9 (a)	59·9 (d)	2·44 (b)	Clay to about 8 or 9 feet deep, then wet sand.
Ardwick	32·1 (k)	41·8 (k)	1·54 (k)	Chiefly clay to a depth of about 10 or 15 feet, then sandstone rock.
Openshaw	41·4 (f)	54·1 (e & f)	1·66 (i)	Chiefly clay to about 9 or 10 feet deep, then sand.
West Gorton	42·7 (e)	54·1 (e & f)	1·89 (e & f)	Hard clay to the depth of any of our sewers, say up to 25 feet.
III. { Rusholme and Kirk	27·2 (m)	35·1 (m)	·91 (n)	Chiefly clay, but in some portions of Rusholme sandstone under the clay at a depth of about 10 or 12 feet.
Chorlton-upon-Medlock	27·0 (n)	34·3 (n)	·87 (o)	Gravel and sand to a depth of about 8 or 10 feet in portions of this district, then sandstone rock ; other portions clay to a depth of about 10 feet, then sandstone rock.
Hulme	38·2 (g & h)	51·6 (h)	1·74 (h)	Chiefly gravel to a depth of about 10 or 12 feet, then shallow bed of clay, afterwards sandstone rock.

NOTE.—The letters in brackets indicate the order of the diarrhoeal death-rate of each township (beginning with the heaviest death-rate) as displayed by the particular method of stating the diarrhoeal death-rate adopted in each column. The variations of position produced by variations of method can thus be seen at a glance.

accurate, is adopted throughout the present investigation. The
results thus obtained will be stated almost entirely diagrammatically
to avoid the printing of elaborate statistical tables, and to enable
the eye to institute comparisons with the minimum of fatigue.   It

Table C.—Great Towns in Order of their Average Annual Death-
rate from Diarrhœa in the Seventeen Years 1882-98 inclusive,
per 1,000 Births.

	Entire Year.	1st Quarter.	2nd Quarter.	3rd Quarter.	4th Quarter.	Percentage of Total Deaths from Diarrhœa occurring in 3rd Quarter of Year.
Halifax	12·4	4·2	5·4	30·3	9·9	61
Huddersfield ...	15·7	5·0	5·1	42·6	10·3	68
Bristol	18·8	6·5	9·1	44·1	15·5	59
Oldham	19·8	7·4	8·3	46·1	17·4	58
Edinburgh	20·9	10·7	12·2	42·2	18·7	50
Plymouth	22·3	3·9	8·9	64·7	11·8	72
Newcastle-upon-Tyne	22·4	4·9	6·3	62·8	15·6	70
Derby	22·6	5·4	6·0	67·2	12·1	74
Birkenhead	23·2	5·7	8·3	68·6	10·2	74
London	23·3	4·7	8·3	70·8	9·5	76
Glasgow	23·9	12·1	14·1	51·7	17·7	54
Cardiff	24·6	6·0	8·8	68·1	15·4	69
Brighton	27·6	3·6	6·5	87·0	13·2	79
Dublin	28·1	10·4	9·3	67·3	25·6	60
Portsmouth	31·4	3·9	7·9	102·0	11·7	82
Sunderland	31·7	4·5	6·8	97·0	18·6	76
Norwich	32·4	3·5	7·1	103·0	16·1	79
Manchester	32·7	9·1	13·4	88·0	20·2	67
Nottingham	33·9	7·1	9·3	102·0	17·1	76
Bradford	34·2	6·8	11·7	98·9	19·3	72
Leeds...	34·3	4·5	8·9	107·0	16·7	78
Liverpool	34·8	6·8	12·5	102·0	17·9	73
Sheffield	35·6	4·8	7·6	116·0	14·0	82
Wolverhampton ...	37·4	7·1	8·5	112·0	21·9	75
Hull	37·9	5·3	8·2	118·0	20·1	78
Birmingham... ...	38·0	7·9	11·2	113·0	19·9	74
Salford	40·7	9·7	14·3	114·0	24·6	70
Blackburn	41·3	16·5	15·0	89·3	35·0	54
Bolton	42·0	10·5	14·2	112·0	31·5	67
Leicester	48·4	3·6	13·3	163·6	13·1	84
Preston	60·4	13·2	19·6	173·0	35·9	72

may be claimed, furthermore, that the diagrammatic method enables
points of resemblance and contrast to be discovered, which would
escape notice had we to deal with a mass of statistical tables.   The
statistics of thirty-one towns have been investigated, viz., twenty-
eight English towns, along with Dublin, Edinburgh, and Glasgow.

For these towns the necessary statistical data are available in the English Registrar-General's quarterly reports, in some instances from 1876, in others from 1882.

Table C summarizes the experience of these towns in the seventeen years, 1882-98 inclusive, the towns being placed in the order of their average annual death-rate from diarrhœa.

In the following table the same towns are placed in the order of their quarterly death-rates from diarrhœa:

Table D.—List of Great Towns in Order of Amount of Diarrhœa in each Quarter of the Year (Mean of 1882-98), beginning with the Town of Lowest Mortality.

	1st Quarter.	2nd Quarter.	3rd Quarter.	4th Quarter.
1.	Norwich.	Huddersfield.	Halifax.	London.
2.	(Brighton.	Halifax.	Edinburgh.	Halifax.
3.	) Leicester.	Derby.	Huddersfield.	Birkenhead.
4.	(Portsmouth.	Newcastle-on-Tyne.	Bristol.	Huddersfield.
5.	(Plymouth.	Brighton.	Oldham.	Portsmouth.
6.	Halifax.	Sunderland.	Glasgow.	Plymouth.
7.	(Leeds.	Norwich.	Newcastle-on-Tyne.	Derby.
8.	(Sunderland.	Sheffield.	Plymouth.	Leicester.
9.	London.	Portsmouth.	Derby.	Brighton.
10.	Sheffield.	Hull.	Dublin.	Sheffield.
11.	Newcastle-on-Tyne.	(London.	Cardiff.	Cardiff.
12.	Huddersfield.	{ Birkenhead.	Birkenhead.	Bristol.
13.	Hull.	(Oldham.	London.	Newcastle-on-Tyne.
14.	Derby.	Wolverhampton.	Brighton.	Norwich.
15.	Birkenhead.	Cardiff.	Manchester.	Leeds.
16.	Cardiff.	(Plymouth.	Blackburn.	Nottingham.
17.	Bristol.	) Leeds.	Sunderland.	Oldham.
18.	(Bradford.	Bristol.	Bradford.	Glasgow.
19.	) Liverpool.	(Dublin.	(Portsmouth.	Liverpool.
20.	(Nottingham.	) Nottingham.	{ Nottingham.	Sunderland.
21.	(Wolverhampton.	Birmingham.	(Liverpool.	Edinburgh.
22.	Oldham.	Bradford.	Norwich.	Bradford.
23.	Birmingham.	Edinburgh.	Leeds.	Birmingham.
24.	Manchester.	Liverpool.	(Wolverhampton.	Hull.
25.	Salford.	Leicester.	(Bolton.	Manchester.
26.	Dublin.	Manchester.	Birmingham.	Wolverhampton.
27.	Bolton.	Glasgow.	Salford.	Salford.
28.	Edinburgh.	Bolton.	Sheffield.	Dublin.
29.	Glasgow.	Salford.	Hull.	Bolton.
30.	Preston.	Blackburn.	Leicester.	Blackburn.
31.	Blackburn.	Preston.	Preston.	Preston.

(Towns bracketed together have an equal death-rate.)

Seasonal Incidence of Diarrhœa.—I have elsewhere dwelt on the disadvantages associated with the statement of average death-rates from a zymotic disease for a series of years, as the towns or districts under comparison may evidently have been affected to a variable extent by the causes of the disease. The above table must be regarded only as a rough preliminary test of the relative status of the towns enumerated in it. It possesses, however, a much higher value as a criterion of the relative seasonal incidence of fatal diarrhœa. We may, therefore, discuss in the first instance this important part of our subject. It will be noted that in all the towns the highest diarrhœal mortality is in the third or summer quarter of the year. The proportion of diarrhœal mortality, however, occurring in this quarter varies greatly, being at the one extreme 50 per cent. of the total annual diarrhœal mortality in Edinburgh, and 54 per cent. in Blackburn and in Glasgow, and at the other extreme 82 per cent. in Portsmouth and Sheffield, and 84 per cent. in Leicester. Obviously a high proportional mortality in the summer quarter might imply either a low mortality in the three other quarters, or an excessive mortality in the summer quarter, or both. It is necessary, therefore, to correct impressions given by the last column in the preceding table by a study of the four preceding columns in the same table.

In some of the towns, *e.g.*, Blackburn, Preston, Glasgow, Edinburgh, and Dublin, diarrhœa has the character of an endemic disease persistently present through every season of the year ; while in towns like Leicester, Norwich, Portsmouth, and Brighton, it partakes much more of the character of an epidemic disease, reappearing in greater or less degree at its proper season, while the amount at other seasons is comparatively insignificant. There is a further distinction. Some of the towns of endemic diarrhœa have a large amount of summer or epidemic diarrhœa (as Bolton and Preston), while in others of them (as Dublin, Edinburgh, and Glasgow) there is comparatively little epidemic diarrhœa. Blackburn is a case requiring further elucidation as to the cause of its uniquely high diarrhœal death-rate in the first quarter, although in the third quarter there are fifteen other towns with a greater amount of fatal diarrhœa. Did time permit, it would be desirable to pursue the study of the seasonal incidence of diarrhœa in much greater detail. For those wishing to do this, the necessary details are contained in the diagrams relating to the thirty-one towns on pages 169 to 210.

Before leaving this branch of the subject, we may raise the question whether any vagaries of medical certification of causes

of death can account for the remarkable differences of seasonal incidence of diarrhœa briefly indicated in the preceding remarks. Is it possible, for instance, that in Blackburn the practitioners are, on the whole, less highly educated than in the other towns, and that thus many ill-defined causes of death are returned as diarrhœa, when the specific disease, which alone is properly indicated by that name, is absent ? I do not think for one moment that any such hypothesis can be substantiated. Still less is it likely to be the case in University cities like Edinburgh and Glasgow, in which also the amount of diarrhœa in the first quarter of the year is very excessive. Nor can the excessive endemicity of diarrhœa in the above cities be explained on the supposition that practitioners of the Scotch and Irish schools certify deaths as from diarrhœa which, by practitioners trained in other schools, would be entered under more definite headings. It must be remembered that we are dealing with towns nearly all of which have a population exceeding 100,000, which implies also that the vagaries of individual medical death-certificates have but little effect in disturbing the total effect. I think, therefore, it may be concluded that the remarkable differences of seasonal incidence of diarrhœa shown in the table on page 146 indicate in the main real facts requiring an explanation, which the facts so far available do not enable us to give.

Our next step is to study the detailed seasonal and annual incidence of fatal diarrhœa in each of the thirty-one towns. This is done in the following diagrams, the towns being arranged in order of their relative freedom from diarrhœa. All the diagrams having been drawn to the same scale (indicated on the left margin as deaths per 1,000 births), are exactly comparable. The lowest part of each vertical column represents the share of each year's diarrhœal mortality occurring in the first, the next portion that in the second, the next that in the third, and the highest portion that in the fourth quarter of each year. It is possible thus to see at a glance the relative share of diarrhœal mortality in each part of a year, and the variations in the incidence of diarrhœa year by year.

For convenience, the diagrams and particulars relating to the towns whose experience respecting diarrhœa is thus graphically stated are placed at the end (pages 31 to 72), in order that the argumentative part of my address may be continuous. Before reading the next pages, however, the reader should examine the diagrams.

Causation of Epidemic Diarrhœa.—Having the elaborate comparative data already given, and the further data on pages 31 to 72 before us, we are in a position to discuss the ætiology of epidemic diarrhœa. Dr. Ballard's report on the subject (issued 1888) was an

interim report, the broad results were stated by him to be provisional only, and it is a striking testimony to his acumen that practically nothing he said needs now to be unsaid. It has always appeared to me, however, a great loss to science that the detailed evidence as to the differential incidence of fatal diarrhœa in different towns, and as to the differences of local conditions associated with these variations, was not published along with Dr. Ballard's provisional statement of results. This was evidently intended to be done in a later report, the publication of which Dr. Ballard's death unhappily rendered impossible. My present contribution may serve in some measure to fill the hiatus thus left.

I should here draw attention to a most valuable paper on "The Causation of Summer Diarrhœa,"* read by Dr. Longstaff before our Society in February, 1880, in which, after giving elaborate statistics, he arrives at the conclusion that " summer diarrhœa is caused by the pollution of air, water, and food with some product or products of the decomposition of organic matter during very hot weather." We cannot, in 1899, be said to have advanced much beyond this point.

A reference to past volumes of our official journal, PUBLIC HEALTH, will discover many other valuable contributions to the elucidation of the problems of epidemic diarrhœa—for instance, on its relation to infant feeding (Dr. Hope) and to public scavenging (Dr. Spottiswoode Cameron).

The results set forth in Table C and in the diagrams on pages 31 to 72 indicate that, although some of the apparent relative freedom from diarrhœa of such towns as Halifax and Huddersfield is caused by the paucity of the infantile population who form its chief victims, there remain great differences for which this statistical explanation will not suffice. In investigating the causes of these differences, and of similar (perhaps even more marked differences) in towns to which I have not been able to extend the inquiry, lies our chief hope of arriving at a true conception of the causation of diarrhœa.

" The causes of infant diarrhœal mortality are multifarious " (Ballard), and that there may be and is a composition of causes is obvious from a perusal of his report, and from the paragraphs on this subject which appear in all annual reports of medical officers of health, and in which congenital debility, maternal industrial occupations, artificial feeding, overcrowding, effluvia from defective drains or from privies or closets, defective scavenging, as well as high temperature of air and soil and deficient rainfall, appear *inter alia* as important factors in the causation of this disease. If, however, we accept the rigid logical definition of cause as the " uncondi-

* Published in the Society's Transactions for 1880-81.

tional invariable antecedent " of a phenomenon, and think of the relation between the two as one of absolute dependence—the effect not merely succeeding to, but proceeding from, the cause—we must narrow our view. But even then we can admit, and in fact necessity requires in this instance, the conception of a composition of causes. Every effect has an ancestry of causes, and every cause a posterity of effects. A spreading ancestry and a spreading posterity are of the essence of causation, from which it follows that primary and subsidiary causes and effects inevitably overlap, and their separation as a means of ascertaining the essential causation of a phenomenon is an extremely difficult problem. It may happen, furthermore, that in separating the factors of causation we shall obtain but an incomplete conception of the origin of a phenomenon, for things, as we know them, are not complete in themselves and self-contained.

The one factor which approaches most nearly to being the " unconditional invariable antecedent " of epidemic diarrhœa is the hypothetical micro-organism, in the absence of which this disease, being a specific febrile disease, almost certainly does not occur. This may be the *Bacillus enteritidis sporogenes* of Klein, but let us hope not, as this particular organism possesses a very persistent vitality. But even this " invariable antecedent " can scarcely claim to be the "unconditional" cause of epidemic diarrhœa. It continues to cause sporadic cases of diarrhœa in our great towns throughout every month of the year, and throughout years in which epidemic diarrhœa is almost absent; but for the occurrence of epidemic diarrhœa certain conditions of temperature and rainfall and soil, and possibly other factors, are required. Some of these factors may now be considered in turn.

A.—In the first place, *epidemic diarrhœa is chiefly a disease of urban life*. Thus, in the rural part of West Sussex the death-rate from diarrhœa in the two years 1897-98 was 10·1 per 1,000 births, as compared with 19·1 in the urban portion of the same administrative county.   A study of Table 27 in the Registrar-General's annual report brings out the same contrast between counties chiefly rural and those chiefly urban, even after ample allowance is made for the lower birth-rates in the former. There is a wide-spread impression that diarrhœa is chiefly a modern disease, which has been the product of the modern urbanization of our population. This is true, because a larger proportion of our population is urban than in the last century. There is, however, less diarrhœa in the urban populations of the present than of the last century. Dr. Creighton claims, and I think rightly,* to have "proved from the London bills of

* " History of Epidemics," vol. ii., pages vii, 763.

mortality of the seventeenth and eighteenth centuries that infantile diarrhœa, which is now one of the most important causes of death in some of the great manufacturing and shipping towns, was formerly still more deadly to the infancy of the capital in a hot summer or autumn." Sydenham in 1669 speaks of the regular appearance of cholera morbus at the end of each summer and beginning of autumn, comparing its regularity to that of the coming of the swallow in spring or of the cuckoo in early summer. "The two worst weeks of an unhealthy summer or autumn raised the London deaths in former times" (eighteenth century) "relatively as much as the whole diarrhœal season would do now."*

The great increase of diarrhœa in the present century is associated with a more than proportional increase of urban population; and it is a satisfactory point that, notwithstanding the steadily increasing urbanization of our population, the death-rate from diarrhœa has decreased from 1,000 per million of population in 1871-75 and 832 in 1876-80, to 667 in 1886-90 and 630 in 1891-95. (Allowance has to be made for lowering of birth-rate and for transference of deaths to other headings.) It is not surprising that in London in the last two centuries diarrhœa should have been so much more fatal than now. As Dr. Creighton puts it, London was "far more urban than now," its streets were narrower, and there were more courts and alleys. Window-taxes were in force, houses were full of effluvia from the "vaults" in the basement, and the whole soil of the city was full of organic impurities, derived from both the living and the dead. It is not difficult to work out points of resemblance between the state of matters in old London and in some of our modern manufacturing towns.

It cannot be said that mere *density of population* (as measured by the number of persons per acre) bears any proportion to diarrhœal mortality. The municipal borough of Brighton has a greater density than any of the other great English towns with two exceptions, and yet there are seventeen other English towns with a higher diarrhœal death-rate. Other instances of discrepancy between degree of density of population and height of diarrhœal death-rate might be given if necessary.

At the census of 1891 information was obtained as to the proportion of total tenements with four rooms and under, and the amount of *overcrowding*, overcrowding being assumed to exist when the number of persons living in a tenement averaged more than two for each room. We may compare in this respect the towns at the two ends of the scale of diarrhœal mortality. (See Table E.)

* Creighton, *op. cit.*, page 763.

Table E.

Town.	Diarrhœal Death-rate Average of 1882-98.	Of 100 Tenements or Dwellings of all Kinds, the Number consisting of Four Rooms, or less than this Number, was	Of every 100 of the Total Population, the Number overcrowded, i.e., living more than Two in a Room, was
Halifax	12·4	69	21·3
Huddersfield ...	15·7	71	19·9
Bristol	18·8	49	8·0
Oldham	19·8	76	10·1
Blackburn	41·3	64	7·0
Bolton	42·0	69	11·2
Leicester	48·4	25	2·2
Preston	60·4	46	4·1

The figures of the last census as to the variations of overcrowding are very extraordinary. If, as is likely, they possess a certain measure of value, the experience of both Halifax and Leicester might be held to indicate that there is an inverse relationship between overcrowding and diarrhœa, which is a *reductio ad absurdum*. All that we can say with safety is that we have not discovered in the preceding statistics any explanation of the great differences in diarrhœal mortality in English towns; and we must leave unanswered, for the present, the question, Why is epidemic diarrhœa chiefly a disease of urban life? We turn next to social and industrial conditions.

B.—*Epidemic diarrhœa as a fatal disease is a disease of the artisan and still more of the lower labouring classes to a preponderant extent.* Although it is difficult to adduce satisfactory class-statistics on this point, the truth of the foregoing statement will be generally admitted. The diarrhœal death rates for the different townships of Manchester (page 7), to those who are familiar with the class-distribution of the population of that city, teach the same lesson. So do the figures for the different districts of London. The lower the social status, the greater is the rate of mortality from diarrhœa. But why? Is it that the mother's attention is distracted from her infant by the necessity of sharing in the earning of the family income, or that the home-conditions are less favourable?

On the industrial occupation and social status of married women, the figures of the last census shed some light. The figures in the first two columns of Table F are taken from a paper by Miss Collett, M.A.*

At first sight Table F appears to support the view that where a large proportion of married women are engaged in non-domestic

* *Journ. Royal Statistical Society*, June, 1898. An abstract of this paper will be found in Public Health, vol. x., p. 374, August, 1898.

occupations a high infantile mortality from diarrhœa is favoured. Preston, Leicester and Blackburn all show this coincidence, Bolton and Salford to a less extent. The sharp contrast in regard to diarrhœal mortality between Oldham and Leicester and between Wolverhampton and Derby, and numerous other inconsistencies in the table, drive one, however, to the conclusion that industrial occupation of women is a contributory, and not a chief, factor in the causation of epidemic diarrhœa. The case of Oldham is particularly instructive in this respect.

Doubtless neglect of infants, implying dirtiness of food, etc., tends to provoke diarrhœa, and only a more intimate acquaintance with the circumstances of local life would enable us to state why a certain amount of industrial occupation of married women should be associated in Oldham with a certain amount, and in Leicester with double

Table F.

Towns in which the Percentage of Wives and Widows between 25 and 45 Years of Age returned as Occupied was in 1891		Percentage of Females above 10 returned as Indoor Domestic Servants, 1891.	Mean Death-rate from Diarrhœa per 1,000 Infants, 1882-98. (See Table C, p. 8.)
At least			
47	Blackburn	5	39
39	Preston	6	60
25	Oldham and Leicester	6	20 and 41
20	Nottingham and Bradford ...	7	33 and 34
15	Birmingham, Bolton, Salford and Manchester	7	38, 41, 40, 33
10	Norwich, Bristol, Huddersfield, Halifax and Leeds	9	31, 19, 16, 12, 34
5	Brighton, Liverpool and Sheffield	11	28, 35, 36
1	Portsmouth, Plymouth, Wolverhampton, Derby, Hull and Cardiff	11	30, 22, 36, 22, 37, 24

this amount, of fatal diarrhœa. It is not likely that in one case it is chiefly the married women without, and in the other chiefly the married women with, families who are industrially employed. Furthermore, the two towns have the same social status as judged by the proportion of domestic servants.

Taking the proportion of females above ten who are returned as indoor servants as a rough test of social status, it is clear that, as a rule, the higher the status, the less the amount of diarrhœa. To what causes may the relative immunity from diarrhœa of infants of a higher social status be ascribed? They are, doubtless, complex, including greater care of infants, more cleanly storage and preparation of food, and especially its storage where it is less likely to receive the specific infection to which epidemic diarrhœa is due.

But social status is not the only factor. Otherwise, why should Oldham, with only 6 per cent. of domestic servants, and Huddersfield and Halifax, with only 9 per cent., have a lower diarrhœal death-rate than Portsmouth, Liverpool, Sheffield, etc., which have 11 per cent. of domestic servants? It is quite conceivable, of course, that the influence of industrial occupation of mothers and of what is connoted by low social status, may, in some of the above instances, be counterbalanced by other factors which are inhibitory to the causation of diarrhœa. Further light will be thrown on this possibility as we proceed.

C.—*Towns which have adopted the water-carriage system of sewerage have, as a rule, much less diarrhœa than those retaining other methods of removal of excrement.* The information obtainable on this point has been stated in full for each town (pages 31 to 72). In the last column of Table G a rough summary is attempted.

Speaking generally, w.c. towns have much less diarrhœa than towns with privy middens. Leicester and Liverpool form exceptions to this rule ; but in both of them there was, before the w.c. period, protracted pollution of the soil, and it is possible that trough closets and other latrines, common to more than one house in Liverpool, tend to keep up the diarrhœal mortality, as well as social factors already mentioned. Of these two, Leicester shows some improvement, Liverpool none, since the adoption of water-closets. Derby, with a considerable proportion of middens, has a very good record for diarrhœa. Several towns having chiefly pail-closets, as Halifax, Huddersfield, and Oldham, occupy a remarkably favourable position. It cannot, I think, be seriously argued, that however carefully the scavenging is done, a pail-closet can, in a town, be as free from nuisance as a w.c.; and I am strongly of opinion that the favourable position of these three towns is notwithstanding the pail-closets, and that they might still further improve their status by a change to the w.c. system. What are the countervailing influences keeping the diarrhœal mortality of these three towns low, notwithstanding the—in my opinion—necessarily unfavourable effect of pail-closets, we shall shortly see.

D.—*Towns with the most perfect scavenging arrangements have the least epidemic diarrhœa.* Here again I must confess my inability to produce exact statistical proof of the thesis thus laid down. It is based, however, on careful inquiry and observation, and it will, I think, be found correct. I include under scavenging the methods of removal of house refuse (*i.e.* dust-bin refuse, and the contents of privies and pails where these exist), and cleansing and washing streets, courts, and yards. Of the two, the removal of house refuse is the more important in this connection, and it is not

possible that local authorities will much longer content themselves with a removal of house refuse at weekly intervals. We most of us distribute official circulars each summer, advising householders

Table G.*

Towns in Order of Diarrhœal Death-rate.	Character of Soil.	Gradients of Town.	Method of Disposal of Excrement.
1. Halifax ...	$\frac{1}{6}$ impervious, $\frac{5}{6}$ pervious	steep ...	about $\frac{3}{4}$ pails, $\frac{1}{4}$ w.c.
2. Huddersfield	mostly impervious ...	steep ...	chiefly pails.
3. Bristol ...	mostly impervious ...	steep ...	w.c.
4. Oldham ...	mostly impervious ...	steep ...	chiefly pails.
5. Edinburgh ...	mostly impervious ...	steep ...	w.c.
6. Plymouth ...	partially impervious ...	rather flat...	w.c.
7. Newcastle-upon-Tyne	impervious	good ...	chiefly w.c., about $\frac{1}{10}$ pails, and $\frac{1}{20}$ middens.
8. Derby ...	mostly impervious ...	good ...	$\frac{2}{5}$ w.c., $\frac{2}{5}$ middens, $\frac{1}{5}$ pails.
9. Birkenhead	mostly impervious ...	fair ...	chiefly w.c.
10. London ...	variable	fair ...	w.c.
11. Glasgow ...	pervious	good ...	chiefly w.c.
12. Cardiff ...	$\frac{1}{2}$ pervious, $\frac{1}{2}$ impervious	good ...	w.c.
13. Brighton ...	pervious	steep ...	w.c.
14. Dublin ...	$\frac{2}{3}$ impervious, $\frac{1}{3}$ pervious	flat ...	w.c.
15. Portsmouth	chiefly pervious... ...	flat ...	w.c.
16. Sunderland	chiefly impervious ...	flat ...	chiefly middens.
17. Norwich ...	pervious	good ...	about $\frac{1}{2}$ middens. $\frac{1}{4}$ pails, $\frac{1}{4}$ w.c.
18. Manchester	partially pervious ...	fair ...	about $\frac{1}{4}$ middens, $\frac{1}{2}$ pails, $\frac{1}{4}$ w.c.
19. Nottingham	pervious	fair ...	$\frac{4}{5}$ pails, $\frac{1}{5}$ w.c.
20. Bradford ...	impervious	rather steep	$\frac{3}{4}$ middens, $\frac{1}{4}$ w.c.
21. Leeds ...	chiefly impervious ...	good ...	about $\frac{1}{2}$ w.c., $\frac{1}{4}$ trough closets, $\frac{1}{4}$ middens, etc.
22. Liverpool ...	pervious	fair ...	w.c.
23. Sheffield ...	chiefly impervious ...	very good	$\frac{4}{5}$ middens, $\frac{1}{4}$ w.c.
24. Wolverhamp- [ton			$\frac{3}{4}$ pails, $\frac{1}{4}$ w.c..
25. Hull ...	partially impervious ...	very flat ...	chiefly middens.
26. Birmingham	pervious	fair ...	about $\frac{1}{8}$ middens, $\frac{3}{8}$ pails, and $\frac{1}{2}$ w.c.
27. Salford ...	impervious	flat ...	$\frac{1}{2}$ middens.
28. Blackburn ...	$\frac{1}{6}$ pervious, $\frac{5}{6}$ impervious	steep ...	$\frac{3}{5}$ middens, $\frac{1}{5}$ pails and $\frac{1}{5}$ w.c.
29. Bolton ...	partially impervious ...	fair ...	$\frac{1}{2}$ middens, $\frac{1}{4}$ pails, $\frac{1}{4}$ waste water and w.c.
30. Leicester ...	partially impervious ...	rather flat ...	chiefly w.c., decreasing number of pails and middens.
31. Preston ...	partially impervious ...	flat ...	chiefly middens, $\frac{1}{4}$ w.c.

* The information summarised in the above table, and given in detail on pages 31 to 72, is derived partly from the annual reports of medical officers of health, partly from direct answers to inquiries (for which I am greatly indebted to my confrères who have thus assisted me), and partly from a valuable report by Dr. Scurfield, dated January, 1897.

to burn all decomposable house refuse. We must, however, recognise the fact that, with the steadily increasing use of gas and paraffin as fuel (particularly in the summer months), this advice is becoming less practicable, and that the responsibilities of local authorities to secure early removal and efficient disposal of such refuse are becoming more weighty. Efficient scavenging of streets and courts is but little less important than house scavenging, and how grievously it is neglected in most towns !

It is impossible for me to enter into a discussion of the relative merits of granite-sets, wood, asphalte, or macadam as road materials. The answer must vary according to local circumstances. The essential point is not to allow organic débris to accumulate, or dust to be scattered about. It is a mere commonplace to state that diarrhœa, like all other infectious diseases, is chiefly caused by organic dust, but this obvious truth needs to be constantly impressed upon local authorities, who are responsible for the removal of dust from our thoroughfares, as well as upon householders who are responsible for domestic organic dust.

Could strictly comparable statistics of the efficiency of scavenging in our great towns be obtained, they would, I am convinced, throw great light upon the relative incidence of epidemic diarrhœa. On this point I must draw attention to a very interesting experiment in local scavenging described by Dr. Spottiswoode Cameron in his annual report for 1892. (See page 165.)

E.—" *The influence of soil is a decided one. . . . Where the dwelling-houses of a place have, as their foundation, solid rock, with little or no superincumbent loose material, the diarrhœal mortality is, notwithstanding many other unfavourable conditions and surroundings, low. . . . On the other hand, a loose soil . . . is a soil on which diarrhœal mortality is apt to be high* " (Dr. Ballard's Report, page 3).

In connection with the statement of the experience of each town (pages 31 to 72) a sketch of the geology of the town has been attempted. The geological characters of a soil can only influence the prevalence of diarrhœa in so far as they affect its physical characters, its permeability to moisture and air, and its facility for the retention or removal of impurities, by natural or artificial means. Given equal care in scavenging (using this term in its widest sense to indicate all artificial measures for the prevention or removal of organic pollution of the air or soil) in different towns, we should expect therefore that the most porous soils would have the most diarrhœa, in accordance with Dr. Ballard's dictum quoted above. To permeability of soil should, I think, be added *gradient*, as an important factor in its power of self-cleansing. In Table G these characteristics of the thirty-one towns in these two respects

are roughly stated. Although every attempt has been made to be accurate, it is possible that in this tabular statement a few inaccuracies may have occurred. I hope that in subsequent discussions more accurate statements on this point will be available, as in all such investigations great difficulties arise in securing vital statistics for districts which are strictly comparable. Thus, if we contrast the diarrhœal experience of a wealthy population on a sandy soil with that of a poor population on a clayey soil, the social position (and what this connotes) of each population and the soil on which each population dwells would to a large extent counteract each other in reference to diarrhœa.

Table G shows that most of the towns with the lowest diarrhœal mortality have impervious soils, though the converse scarcely holds good. Thus, Preston, Bolton, and Salford, with partially or completely impervious soils, have a high diarrhœal mortality ; while it is clear that in Halifax, with a largely pervious soil, good scavenging, or impervious paving, or some other factor, prevents the pollution of soil which is probably the important element in the causation of diarrhœa in towns on pervious soils. Steep gradients are mostly associated with a low diarrhœal mortality. But these are mostly found in towns with a heavy rainfall, as we shall shortly see.

F.—Much can be said in favour of the view that differences as to rainfall and temperature explain the varying incidence of diarrhœa. I would go so far as to say that, *given two towns equally placed so far as social and sanitary conditions are concerned, their relative diarrhœal mortality is proportional to the height of the temperature and the deficiency of rainfall of each town, particularly the temperature and rainfall of the third quarter of the year.* There is perhaps nothing new in this view, but it is important to crystallize it into a short statement, as I am confident that under present conditions of life there is an irreducible minimum of epidemic diarrhœa each year, the amount of which is dependent solely upon the uncontrollable climatic conditions enumerated above. Let me place in apposition to the above statement the statement of Dr. W. Johnston, formerly Medical Officer of Health of Leicester, who, after many years' experience of diarrhœa in its chief English home,* emphasized the view that meteorological conditions act only as excitants of the disease, in the following words : " I feel assured that if we could discover any particular town or district whose sanitary machinery was in perfect working order, the vicissitudes of climate would there be found to be perfectly harmless in the production of disease." He went on to state that under the then conditions " a continuance for a week or ten days of a mean daily

* *Lancet*, September 28, 1878.

temperature of 59° F. or over, in conjunction with a scarcity of rainfall and low degree of humidity of air, occurring during any period from the twenty-fifth to the thirty-seventh week of the year, is sufficient either to provoke the disease or to increase its prevalence." In theory we must agree with Dr. Johnston; a high temperature or deficient rainfall is not the *causa causans* of diarrhœa. This is a special micro-organism. But these climatic conditions play as indispensable a part in the causation of diarrhœa as does the weather of summer in growing our cereal foods. The analogy may be pushed further. Neither the summer weather nor the actual seeds suffice for the summer crop of diarrhœa or of wheat, a suitable soil (in the former instance a polluted soil) being required for it to assume active virulence.

If temperature of air and deficiency of rainfall be such important factors in the causation of diarrhœa, a comparative examination of the towns in these respects may throw some light on our problem.

In Table H I have arranged the towns from which the information could be obtained in the order of their temperatures. In the first column is given the sum of the mean annual temperatures for 1891-98 inclusive; in the second the sum of the mean temperatures of the third quarter in each of the same years; in the third the sum of the annual rainfall; in the fourth the sum of the third quarters' rainfall for the same years; and in columns 5 and 6 are given the sum of the annual diarrhœal death-rates and of the death-rates from diarrhœa in the third quarters of the years 1881-98.

Epidemic diarrhœa differs from diseases like diphtheria and rheumatic fever in that it becomes epidemically prevalent after a few weeks' persistence of the favouring climatic conditions; while I have elsewhere* shown that more than a single year's prevalence of the favouring climatic conditions is required for the production of a major epidemic of the latter diseases.

We may expect, therefore, that epidemic diarrhœa will, *ceteris paribus*, prevail in different towns, in the aggregate of a number of years, in proportion to their position in relation to temperature and rainfall. This point is tested in Table H.

The facts in Table H, dealing with the only fourteen great towns for which I could obtain a comparable series of observations, will be more comprehensible when these facts are stated as a percentage deviation from the average for all the towns. This is done in Table I.

It is clear that whether the records for the third quarter of the year or for the entire year are taken, the towns with the lowest

* See Milroy Lectures, *Lancet*, May 9th and 16th, 1895, and "Epidemic Diphtheria." p. 157 *et seq.*

Table H.—Towns arranged in Order of the Sum of Average Annual Temperatures, 1891-98.

SUM FOR THE YEARS 1891-98 INCLUSIVE OF

	Mean Annual Temperature of Air.	Mean Temperature of Air in 3rd Quarters.	Mean Annual Rainfall.	Mean Rainfall in 3rd Quarters.	Annual Death-rate from Diarrhœa per 1,000 Births.	Death-rate from Diarrhœa in 3rd Quarters per 1,000 Births.
	(1)	(2)	(3)	(4)	(5)	(6)
Brighton	399·0	478·5	217·3	56·8	913·9	713·5
London	398·5	484·6	177·5	51·9	773·5	582·9
Portsmouth... ...	395·6	477·2	216·3	59·4	955·5	864·7
Norwich	391·1	466·0	200·0	55·0	1026·2	806·9
Liverpool	386·4	459·8	222·7	68·0	1176·5	874·8
Leeds	384·9	465·6	208·2	55·4	1135·1	919·1
Bristol	384·0	461·2	244·4	78·4	636·2	369·8
Bradford	383·8	460·4	22S·4	57·8	1013·6	834·4
Nottingham ...	381·2	460·0	173·8	49·0	1171·4	868·6
Hull...	378·4	454·3	205·8	56·4	1392·1	1217·7
Huddersfield ...	378·1	457·6	265·2	61·0	512·3	368·7
Oldham	374·0	462·0	313·3	90·5	817·4	512·5
Halifax	369·0	447·5	265·8	60·9	415·4	206·9
Wolverhampton ...	367·1	447·7	186·0	47·8	1340·2	1054·7
Sum of 14 years ...	5371·1	6482·4	3125·7	848·3	13279·3	10195·2
Average for 14 years	383·6	463·0	223·2	60·6	948·5	728·4

Table I.—Towns arranged in the Order of their Diarrhœal Death-rate.

PERCENTAGE DEVIATION FROM THE AVERAGE IN FOURTEEN TOWNS OF

	Death-rate from Diarrhœa.	Rainfall.	Mean Temperature of Air.	Death-rate from Diarrhœa.	Rainfall.	Mean Temperature of Air.
	In the 3rd Quarters of the Years 1891-98 inclusive.			In the Entire Years 1891-98 inclusive.		
Halifax	− 71	+ 1	− 3	− 56	+20	− 4
Huddersfield ...	− 49	+ 1	− 1	− 46	+19	− 1
Bristol	− 49	+29	0	− 33	+ 9	0
Oldham	−39	+50	0	− 14	+40	− 3
London	− 20	− 14	+5	− 18	− 20	+4
Brighton	-- 2	− 6	+3	− 4	− 2	+4
Norwich	+11	− 9	+1	+ 8	− 10	+2
Bradford	+15	− 4	0	+ 7	+ 3	0
Portsmouth ...	+19	− 2	+3	+ 1	− 3	+3
Nottingham ...	+19	− 19	0	+23	− 22	− 1
Liverpool	+20	+12	− 1	+24	0	+1
Leeds	+26	− 8	+1	+20	− 7	0
Wolverhampton ...	+45	− 21	− 3	+41	− 17	− 4
Hull	+67	− 7	− 2	+47	− 8	− 1

diarrhœal mortality have the greatest rainfall and the lowest temperature, and *vice versâ*. In Table I the fourteen towns are given in the order of their death-rates from diarrhœa. All the towns with excessive rainfall (except Liverpool) and all the towns with low temperature (except Liverpool, Wolverhampton, and Hull) in the third quarter of the year have a low diarrhœal mortality ; while the converse is true for the towns with deficient rainfall and high temperature (except for rainfall in London and in Brighton). Similarly, for the entire year all the towns (except Bradford) with excessive rainfall, and all the towns with low temperature (except Wolverhampton and Hull), have a low diarrhœal mortality ; while the converse is true for the towns with deficient rainfall and high temperature (except London and Brighton).

The next point is whether any quantitative proportion can be detected between the above meteorological factors and the amount of diarrhœa. The answer is negative. Thus, Oldham, with a third quarter's excess of rainfall of 50 per cent., has more diarrhœa than three other towns. At the same time its mean temperature is slightly higher than two of these three.* Similarly, Hull, with a deficiency of 7 per cent. of rainfall, has an excess of 67 per cent. of diarrhœa, as compared, for instance, with a deficiency of 8 per cent. of rainfall in Leeds, and an excess of diarrhœa of 26 per cent. Hull has the further advantage that its third quarter's mean temperature is 2 per cent. below, while that of Leeds is 1 per cent. above, the average.†

Liverpool is another interesting example ; for with rainfall and temperature in its favour (less so for the whole year than for the third quarter) it has an excess of 20 per cent. of diarrhœa. On the other hand, both London and Brighton occupy a more favourable position than would be expected on meteorological grounds.‡

* For further remarks on Oldham, see pages 16 and 35.

† The Yorkshire series is particularly interesting. Arranged in order of rainfall in the third quarter, we have Halifax, Huddersfield (nearly equal), Bradford, Hull, Leeds, which, excepting Hull, is also the order of diarrhœa.

‡ Meteorological observations for Preston in 1894 are lacking. As this town has the highest diarrhœal mortality, I add the following comparative table for the seven years, 1891-98, omitting 1894 :

Sum for the Years 1891-93, 1895-98, inclusive of

	Mean Annual Temperature of Air.	Mean Temperature of Air in 3rd Quarter.	Mean Annual Rainfall.	Mean Rainfall in 3rd Quarter.
Preston	346·0	418·0	235·7	81·6
Leeds	336·4	408·6	170·1	49·7
Bristol	335·9	405·7	203·7	67·2
Halifax	322·7	393·0	228·4	54·1

Tables H and I appear to me to hold out some hope of our ascertaining more accurately the true position of each town as regards epidemic diarrhœa. This position is the resultant of two forces—(*a*) the natural forces of nature, rainfall, and temperature, which are *inevitable;* and (*b*) the sanitary and social conditions of each town, which are in a large measure *evitable.*

If accurate and continuous meteorological observations were kept in every town, we should be able to arrange the towns in the order in which they should appear *re* diarrhœa, and contrast this with the actual position of each town. If a standard of comparison were taken, a series of meteorological *factors of correction* might be devised, though this is an unnecessary refinement, and is only mentioned as indicating the need for allowance for meteorological conditions in determining the relative position of towns in respect of diarrhœa. In Table H fourteen towns are arranged in the order of their aggregate mean annual temperatures for eight years. Brighton, which ought on this basis to have the highest diarrhœal mortality, is lower than eight of the fourteen towns. Oldham ought, if annual rainfall be taken as our guide, to have the lowest diarrhœal mortality, but it is surpassed by three others. Notwithstanding these discrepancies, there is *a general inverse relationship between rainfall and diarrhœa and a direct relationship between temperature and diarrhœa;* and the discrepancies merely indicate that other factors are in operation, concealing to some extent the operation of these natural agents. What these other factors are must be the subject of special investigation in each town. The soil as a cause of diarrhœa may be largely obviated by impervious paving in streets and yards, and by impervious flooring to houses. Under the head of scavenging (in the wide sense previously indicated) will, I think, be found the chief evitable causes of diarrhœa. They furnish ample scope for sanitary work. It must not be understood that, in the towns having less diarrhœa in Table I than their meteorological position would lead one to expect, the ideal has been attained. Even the best of them has to thank its meteorological and physiographical circumstances for a large share of its comparative freedom from diarrhœa, and could, with the carrying out of perfectly practicable sanitary measures, still further reduce the incidence of diarrhœa.

Thus, mean aerial temperature being taken as a standard, Preston ought to have, as it has, the highest diarrhœal death-rate. If rainfall be taken as the standard, whether rainfall for the entire year or for the third quarter be considered, Preston ought to have the lowest, whereas it has the highest, diarrhœal death-rate of the four towns enumerated above. It is clear that other conditions than meteorological are the chief determining causes of its excess of diarrhœa.

I have hitherto spoken of temperature and rainfall in conjunction. The two are mutually interdependent, and it is, I think, unnecessary, even if it were practicable, to think of them as separate causes of freedom from or prevalence of diarrhœa.   A careful study of Table I has led me to the conclusion that the incidence of diarrhœa follows more closely the rainfall than the mean temperature of the air.* Wolverhampton and Hull are striking examples of this, and so, in the opposite direction, are London and Brighton.

Hitherto I have not mentioned earth temperatures.   And I have taken mean temperatures of the air (these being alone available), although Dr. Siebert† and others have expressed the opinion that the important element is the minimum temperature.   Dr. Miller has emphasized the importance of recognising that the effect of the sun on the earth is cumulative.   This consideration led to the first taking of earth temperatures, first begun in this country at Leicester, following the method of Pfeiffer (1871) for Asiatic cholera.‡   The number of observations of soil temperature in our great towns is scanty.   The following are the only examples I have obtained, and these could not all be obtained in a comparable condition for more than three years :

AGGREGATE OF MEAN ANNUAL EARTH TEMPERATURES AT A DEPTH OF 4 FEET IN THE THREE YEARS, 1896-98.

	Entire Years.	3rd Quarters.
Preston	150·1	170·2
Portsmouth	156·6	184·1
Brighton	157·3	181·4
Oldham	143·	166·
Huddersfield (at depth of 4 feet 6 inches) ...	142·7	161·9

Oldham fits in with the rule of relationship between low earth temperature and low diarrhœa.   It will be seen that in this town the average soil temperature of the third quarter does not reach Ballard's critical 4-foot earth temperature of 56° F.   Preston, however, with a lower earth temperature than either Portsmouth or Brighton, has an immensely higher diarrhœal mortality.   Ballard's statement that " the summer rise of diarrhœal mortality does not

* While this paper is being printed, my attention has been drawn to the following remarks by Mr. Buchan : " At Leicester the summer temperature does not exceed that of Bristol. . . . It may be assumed that there are local peculiarities affecting the population of Leicester, the effect of which is to quadruple the death rate from diarrhœa in that town as compared with Bristol " (*Trans. San. Inst.*, vol. vii.).

† Quoted from *New York Med. Rec.*, vol. i., 1888, page 317, by Dr. Dawson Williams in " A Note on the Circumstances under which Warm Weather determines the Prevalence of Cholera Infantum " (*Occidental Medical Times*, September, 1889, p. 523).

‡ Creighton, *op. cit.*, vol. ii., page 762.

commence until the mean temperature recorded by the 4-foot earth thermometer has attained somewhere about 56° F., no matter what may have been the temperature previously attained by the atmosphere or recorded by the 1-foot earth thermometer," appears to imply that air temperatures and 4-foot earth temperatures may give contrary indications respecting diarrhœa. I do not think this is so. I think that the relationship between diarrhœa and temperature may be stated with almost equal approximation to accuracy by Ogle's as by Ballard's rule. Dr. Ogle said :* " Speaking generally, it appears from the returns of mortality in London that the diarrhœal mortality becomes high when the mean weekly temperature " (of the air) " rises to about 63° F." Mr. Symons, F.R.S., has contended the same point. In the *Meteorological Magazine*, xxvi., 1891, page 130, he has shown that the dates of the maximum and minimum temperatures of the soil are retarded in regular sequence about five days for each increase of 1 foot in depth ; " therefore to say that any disease occurs a fortnight after the soil temperature at 4 feet reaches any given point is very much the same as saying that it does so thirty-four days after the air temperature has reached another given point." I should not lay stress on this point were it not for the fact that the general adoption of Dr. Ballard's rule, as an axiom of medical science, has perhaps led to a pessimistic view in regard to the prevention of diarrhœa. If the occurrence of diarrhœa is connected with vital processes in polluted soil at a depth of 4 feet, preventive measures must be arduous if not impracticable. (Ballard himself, in his provisional hypothesis, states that " the essential cause of diarrhœa resides ordinarily in the *superficial layers* of the earth.") There are the strongest reasons for believing that the contagia of certain other diseases have a saprophytic stage of existence below the surface of the soil, and that for their epidemic prevalence comparative drought and its associated condition of comparatively high soil temperature enduring more than one year are necessary conditions (see page 21). But as regards diarrhœa, each epidemic recurs with mechanical regularity each summer, within a short time (measured by days or weeks) of the recurrence of the favouring temperature ; and the evidence appears to me to point to the conclusion which I stated in an official report in May, 1891, and which additional observation tends to confirm : " Diarrhœa is due to *surface* accumulations of offensive matter in the neighbourhood of houses, in ill-constructed and imperfectly emptied ashpits and elsewhere, rather than to a polluted subsoil." At the present time, I would lay emphasis not only on obvious collections of organic

* Supplement to the Forty-fifth Annual Report of the Registrar-General, 1885.

refuse, but also on the less obvious but probably almost equally dangerous surface pollution of backyards and streets by organic refuse, which subsequently gains access as fine dust to houses, and poisons the domestic food.

I have hitherto spoken of unfavourable meteorological conditions in a given town as being outside the scope of human control. This is not entirely true. If the natural scavenger—rainfall—fails, it may to a certain extent be supplemented by that "swilling" of streets and yards which, except in the Northern counties and in Scotland, has almost entirely gone out of fashion. Here I may allude to the comparative freedom of Scotch towns from diarrhœa (see Table C, page 8), which is, I believe, in part due to the greater liberality with which Nature has provided its natural scavenger, and in part due to the greater efficiency of municipal scavenging in the same towns. And on this point I find myself supported in a valuable paper by Dr. Hope,* which will well repay study. Comparing 1891 and 1895, he states that in the wet summer of 1891 (with a diarrhœal mortality only one-fourth of that in 1895), upwards of 900 million gallons of water were distributed in Liverpool by rain, which were absent in 1895. He adds, "The water supplies of cities for public cleansing purposes should be free and unstinted." If my address serves to re-emphasize this practical point, it will amply repay me for the labour expended in its preparation. It will be noted that the efficiency of "swilling" courts, yards, and streets in the prevention of diarrhœa is conditional on the surface presence of the diarrhœal contagium, as, under the conditions of town life such "swilling" cannot be expected materially to affect the 4-foot earth temperature.

In 1892 an interesting experiment in scavenging was carried out in Leeds† by Dr. Spottiswoode Cameron. One district, comprising nearly one-tenth of the whole, was specially scavenged on the approach of summer. This was the only district in Leeds in which, as in other towns, the diarrhœal death-rate did not exceed that of 1891,‡ with the exception of one other district, in which, without

* Public Health, vol. xi., July, page 660.

† Public Health, vol. vi., page 153.

‡ In this particular district of Leeds, which is chiefly a poor one, the death-rate from diarrhœa per 1,000 of population decreased from 7·00 to 6·47; while the death-rate in the rest of Leeds, less the district specially scavenged, increased from 3·07 to 5·08. The extra scavenging comprised more frequent sweeping of streets and yards (than formerly or than in the rest of the town). Two extra carts were put on to flush drains and gullies. The removal of refuse, contents of tubs, privies, and dry ashpits, was more effectually carried out in this district than in the rest of the city, and than in former years (Dr. Spottiswoode Cameron).

any change in scavenging, the diarrhœal death-rate was the same as in the previous year.

G.—We are now in a position to summarize the evidence already adduced.

(a) It is clear that towns with a high temperature and a deficient rainfall, especially in the third quarter of the year, suffer severely from diarrhœa. This relationship is so close that the towns may be classified meteorologically in the order in which they ought to stand in reference to diarrhœa, and their true relative position as to domestic and municipal sanitation may be ascertained when we know whether they occupy a better or worse position on the list of towns than that which their meteorological place would indicate as rightly belonging to them.

(b) It is clear that among populations living on impervious and rocky soils diarrhœa is not so prevalent, probably because polluting fæcal and other organic impurities do not cling to or soak into such soils.

(c) Diarrhœa is most prevalent where the systems of removal of sewage and house refuse are the least satisfactory. The exceptionally good position of certain towns in which pail-closets are largely used must be regarded as due to the favourable climatic and physiographical position of these towns, probably aided by efficient municipal scavenging; and it is almost certain that their position might be still further improved by the general adoption of a water-closet system.

The fundamental condition favouring epidemic diarrhœa is *an unclean soil, the particulate poison from which infects the air, and is swallowed, most commonly with food, especially milk.*

In other words, epidemic diarrhœa is, like enteric fever, a "filth-disease." There are, however, certain points of contrast between the two diseases. In the Annual Summary of the Registrar-General for 1898 is a table giving the average death-rates for diarrhœa and enteric fever, 1888-97. This table shows that although some towns have a low diarrhœal and a low typhoid mortality, *e.g.*, Croydon, Bristol, and Huddersfield, and the association of a high mortality from both diseases is also common, *e.g.*, Blackburn, Bolton, Preston, and Salford, there is no necessary association between the position of the towns in these two respects. Sunderland is worst (thirty-third) on the list for fever, only twenty-third for diarrhœa; Swansea is thirteenth for fever, third for diarrhœa; Brighton is second best for fever, only eighth among thirty-three towns for diarrhœa, and so on. The clue to the difference of incidence of the two diseases will, I think—apart from the fact that enteric fever is a disease more

particularly of adults, who are in the habit of taking infected foods, not eaten by infants—be found in the view that the causation of diarrhœa is most closely associated with surface pollution of the soil, that of enteric fever with less superficial pollution of the subsoil from cesspools and leaky drains, as well as from privy-middens.

It will be noted that I have hitherto refrained from discussing the influence of artificial feeding of infants with cow's milk in the causation of diarrhœa. To many this will seem like the play of *Hamlet* without the Prince of Denmark. My silence is not due to non-recognition of the importance of this factor. Milk is, however, not the actual cause of diarrhœa. It is a vehicle of infection, just as mosquitoes are a vehicle of malaria, or rats of plague ; and our ultimate research ought to be directed towards elimination—if it be practicable—of the actual conditions under which the contagia of these diseases are able to live. If we throw further light on these primal causes, we are in a better position to attack the vehicles of infection ; and failing removal of the primal causes, we can then, to the best advantage, break the chain of causation at a point nearer the sufferer. If $A =$ the favouring climatic conditions in the absence of which the contagium of diarrhœa does not multiply, $B =$ the domestic and municipal cleanliness (removal and prevention of organic dust) which prevents the accumulation of this contagium, and $C =$ the milk to which this contagium gains access, and along with which it enters the alimentary canal, B and C are evidently the factors of causation which we can hope most successfully to combat.

The question arises whether milk most commonly receives the contagium of diarrhœa at its source on the farm, in transit, or during delivery and storage at home. The last is, I believe, the most common point of infection, though the filthy conditions under which cows are commonly milked must largely help in the same direction.

Infants being suckled usually escape epidemic diarrhœa. This immunity is, so far as my local experience is concerned, not so absolute as might be expected—a fact which serves to emphasize the possibilities of infection by dust, apart from food. It is probable that much adult epidemic diarrhœa—which, although it does not figure largely in our death-returns, is extremely prevalent during hot summers—owes its origin similarly to the infected dust of our city streets and alleys, swallowed apart from food. Nor, although I cannot enlarge on this point, should the possibilities of personal infection be ignored. Multiple cases in the same house I have found to be fairly common ; occasionally adults are infected by

3

infants, sometimes the reverse. When we remember how common are secondary and tertiary cases of enteric fever in houses where unskilled nurses are employed to nurse the first patient, it is not surprising that the same should hold good for diarrhœa.

These, and many other points which suggest themselves, must be left for further investigation. I have already exceeded the limits of my time and space. I venture to express the hope, in conclusion, that the present address may lead others to give more detailed facts relating to local experience and to the success attending local efforts at prevention of this disease, including methods of improved scavenging, better paving, reduction of dust in our streets, impervious paving of yards and alleys, the substitution of the water-carriage system for privies, and the municipal supply of sterilized milk, as in the interesting experiment at St. Helens. If during the present year's history of our Society each Branch were to invite and receive contributions on this subject, based on local experience or on special investigation, it would be found at the end of the year that we had done a piece of splendid work in the advancement of the public weal.

Halifax.

Physiography.—The town is divided into two by a brook.   On one side the soil is impervious clay (population, 16,000) with a considerable dip to the brook.   On the other the town is entirely built on pervious sandstone (millstone grit) of considerable depth, having a population of about 80,000.   The gradients on this side of the
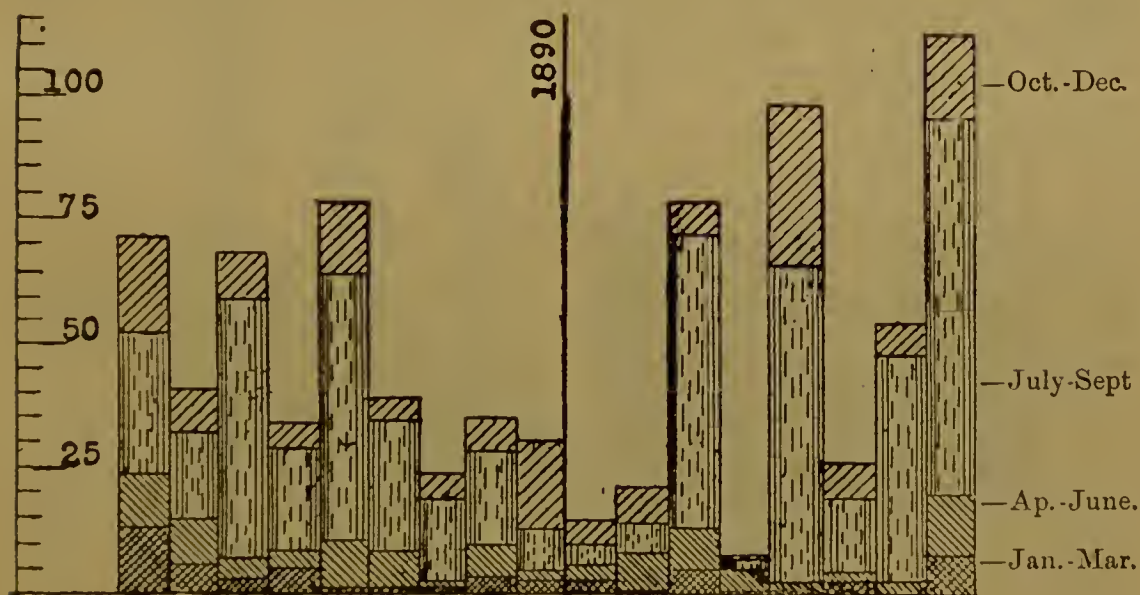
Fig. 2.—Halifax (1882-98).

Population estimated 1882 = 74,713.
         ,,   ,,   1898 = 96,729.

stream are very gradual, and from west to east.—*Letter from Dr. Ainley, M.O.H.*

Conservancy System.—About 14,000 pails (Goux system), 4,000 w.c.'s, and 625 ashpits with privies.

Course of Diarrhœa.—The average annual death-rate, 1882-98,

3—2

was 12·4,* in the third quarter 30·3, per 1,000 births. The mortality
in the lowest (first) forms 14 per cent. of that in the highest (third)
quarter of the year. For the first quarter it occupies the fifth, for
the second the second, for the third the first, and for the fourth
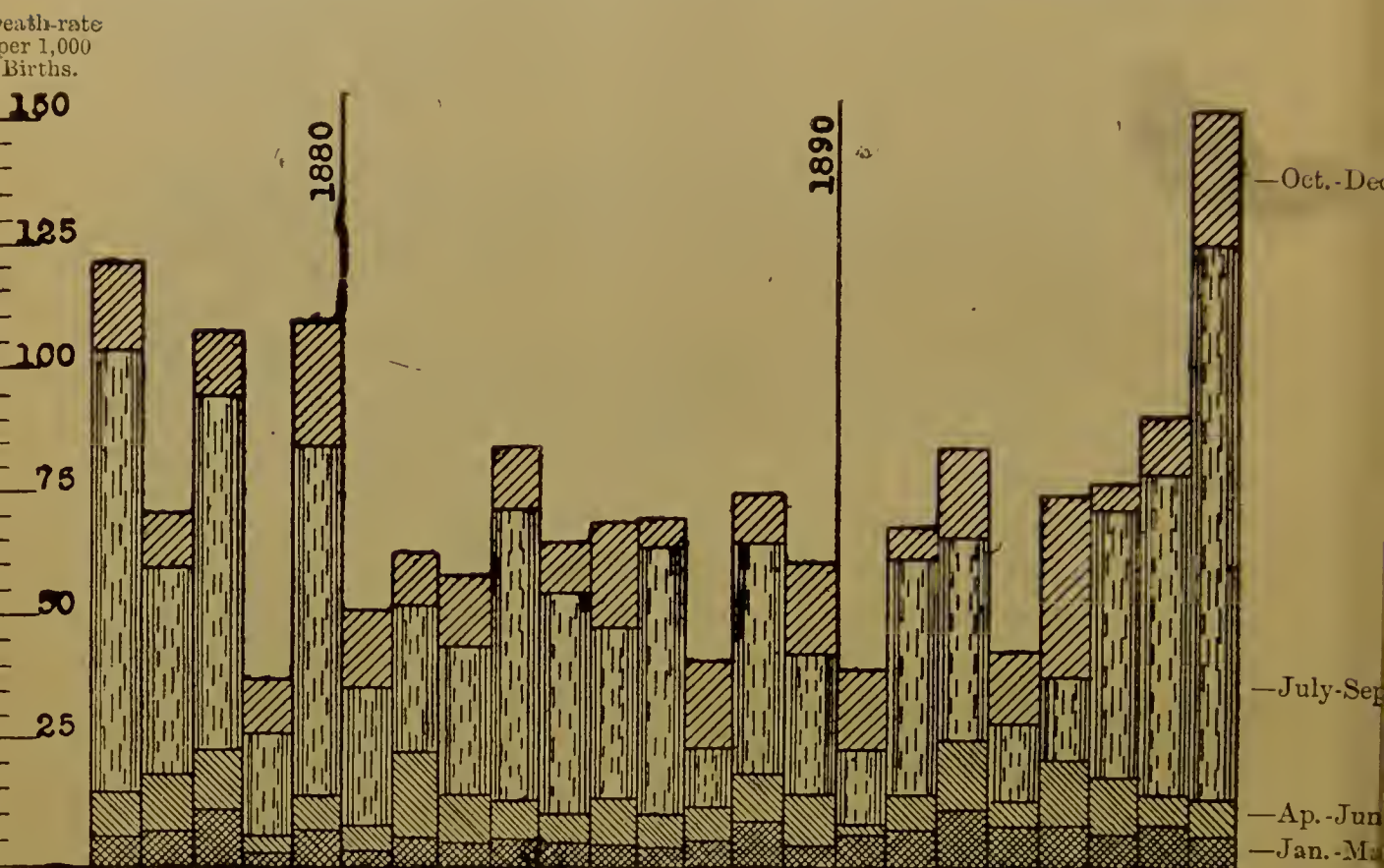quarter the second, place among the towns in Table C. For the year
as a whole it has the premier position among the great towns, there
being a remarkably low mortality from both endemic and epidemic
diarrhœa.

Huddersfield.

Physiography.—The greater portion of the town is situated upon
layers of coal, ranging from thin coal and fireclay, through soft bed-

Death-rate
per 1,000
Births.
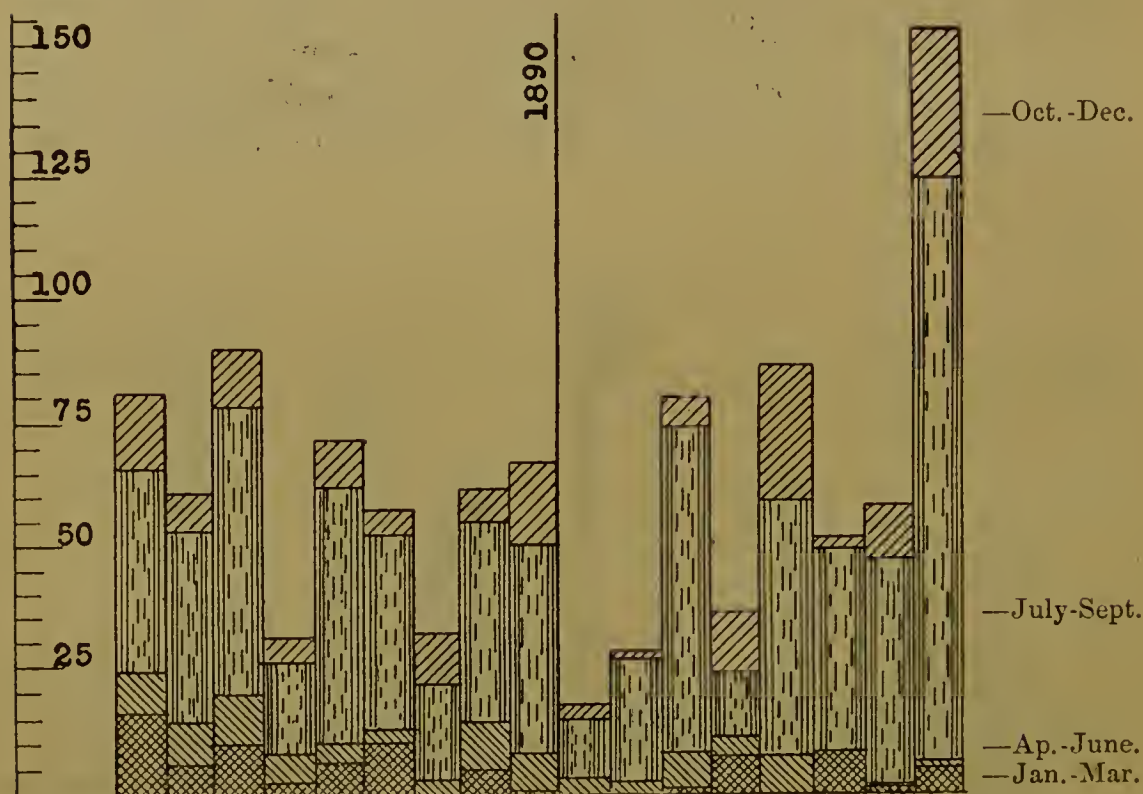
FIG. 3.—HUDDERSFIELD (1882-98).

Population estimated 1882 = 83,418.
    „   „   1898 = 102,454.

flag, soft bed-coal, middle hard bed-coal, and rock, to the better
bed-coal and fireclay strata, which are all comprised in the lower

* To avoid confusion, it may here be indicated that in each diagram (Figs. 2
to 32) the height of the column for each year, being the sum of the diarrhœal
death-rates for the four quarters of the year, is *four times* the annual death-
rate from diarrhœa mentioned in Table C (page 8). See also remarks on
page 11.

coal-measures or ganister beds of the carboniferous rocks. The remaining portion (population about 19,000) is upon sand, rock, flags, shales, and sandstone. Generally the former soil is somewhat impervious, the water being held more upon its surface by the clay overlying the coal, while the latter soil is drier. The gradients of the town are generally fairly steep, varying from about 150 feet above sea-level at Colne Bridge to about 1,000 feet at Castle Hill. The higher parts with the greater gradients are on sandstone, the lower parts on less pervious material, the greater part the truly urban population being on the latter.—*Letter from* ... *is, M.O.H.*

Conservancy System.—Is chiefly a pail-closet town. In 1896 there were 15,000 pails, and 3,143 w.c.'s. The proportion of the latter is increasing *

Course of Diarrhœa.—The average annual death-rate, 1882-98, was 15·7, in the third quarter 42·6, per 1,000 births. The mortality in the lowest (first) forms 12 per cent. of that in the highest (third) quarter of the year. For the first quarter it occupies the twelfth, for the second the first, for the third the third, and for the fourth quarter the fourth, place among the towns in Table C. Thus, there is remarkably little diarrhœa both of the endemic and the epidemic type. This has been the case throughout the years displayed in the diagram, the condition of the town *re* diarrhœa being almost stationary, if 1898 be excluded.

Bristol.

Physiography.—The old city is situated chiefly on low ground in a broad valley lined by the alluvial deposit of the river Avon. Parts of the city are upon higher ground on the new red sandstone (trias), through which rock the New Cut, or artificial course of the Avon, has been cut. The high tableland of Clifton, Cobham and Redland to the north and west of the city is situated upon the denuded edges of an arch of carboniferous rocks, upon which in certain limited areas beds of newer formation (*e.g.*, lias) lie unconformably. The steep ascents ascending from Granby Hill on the west past Brandon Hill to St. Michael's Hill and Marlborough Hill on the east are on the outcrop of the millstone grit.—*Dr. Davies, Annual Report*, 1898.

Thus, the greater part of the city is on comparatively impervious strata (viz., alluvium and new red marl). There are many steep slopes in the city.

* Dr. Annis informs me that at present (1899) there are 12,604 tub closets, 4,742 fresh water-closets, 180 slop water-closets, 8,017 dry ashpits, and 1,209 privy middens in Huddersfield.

Conservancy System.—Entirely a w.c. town, and has been for a long time.

Course of Diarrhœa.—The average annual death-rate, 1882-98, was 18·8, in the third quarter 44·1, per 1,000 births. The mortality in the lowest (first) forms 15 per cent. of that in the highest (third) quarter of the year. For the first quarter it occupies the seventeenth, for the second the eighteenth, for the third the fourth, and for the

FIG. 4.—BRISTOL (1876-98).

Population estimated 1876 = 199,539.
  ,,   ,,   1898 = 316,900.

fourth quarter the twelfth, place among the towns in Table C. There is a relatively large amount of præ-epidemic and post-epidemic diarrhœa and very little epidemic diarrhœa. The amount of total diarrhœa has remained about stationary during the years shown in the diagram. Possibly there is a little increase, if allowance be made for alterations in nomenclature (see page 6). The same caution holds good for the diagrams giving the experience of every other great town.

Oldham.

Physiography.—Is situated chiefly upon the boulder clay with some sand, the deep strata consisting of rock shale. There are numerous faults. Generally speaking, the soil is described by Dr. Wilkinson, M.O.H., as being impervious. The gradients are high, varying from 354 feet to 1,225 feet above sea-level. Dr. Wilkinson adds that he attributes the freedom of Oldham from diarrhœa "to the elevation of the centre of the town causing a
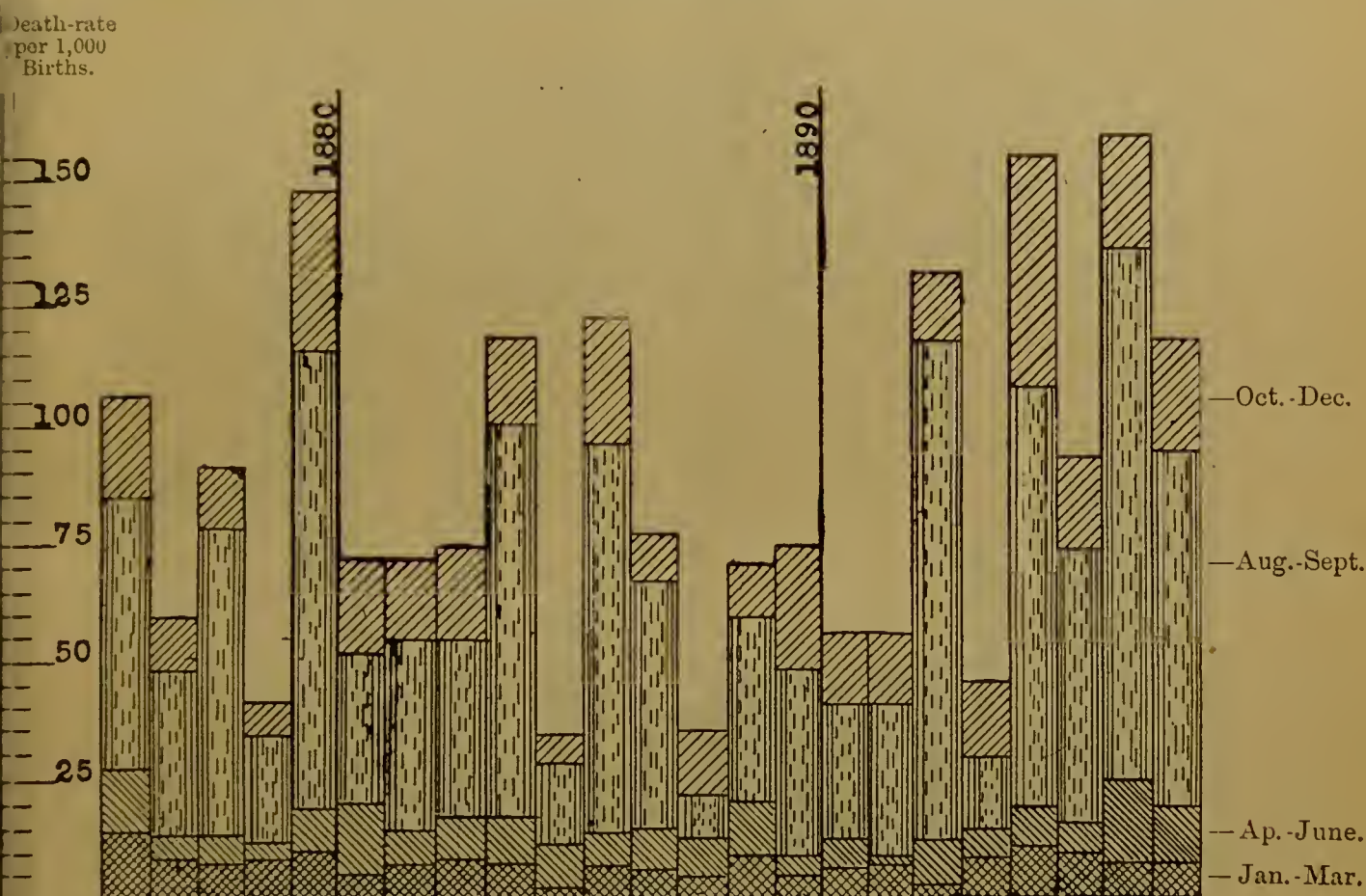
FIG. 5.—OLDHAM (1876-98).

Population estimated 1876 = 88,609.
        ,,   ,,   1898 = 148,288.

natural drainage, and a cooler atmosphere and soil-surface. There is only a very small proportion of the town which may be considered flat. We are rather liable also to heavy storms of rain, which wash the surface of the ground, and are rapidly discharged into the sewers."

Conservancy System.—In July, 1899, the number of pails was 23,810 ; of iron tanks, cesspools, etc., 41 ; of water-closets, 1,797 ; of waste-water closets, 1,523 ; of trough-closets, 301.—*Dr. Wilkinson.*

Course of Diarrhœa.—The average annual death-rate, 1882-98, was 19·8, in the third quarter 46·1, per 1,000 births. The mortality in the lowest (first) forms 16 per cent. of that in the highest (third) quarter of the year. For the first quarter it occupies the twenty-second, for the second the tenth, for the third the fifth, and for the fourth quarter the seventeenth, place among the towns in Table C.

Oldham occupies a relatively bad position for præ-epidemic and post-epidemic, and a remarkably good position for epidemic, diarrhœa. It has deteriorated in recent years in respect of total diarrhœa.

Edinburgh.

Physiography.—It is chiefly built on boulder clay, an impervious stratum. The gradients are very steep, especially in the Old and New Town ; the slopes of the outlying suburbs are also good, but not
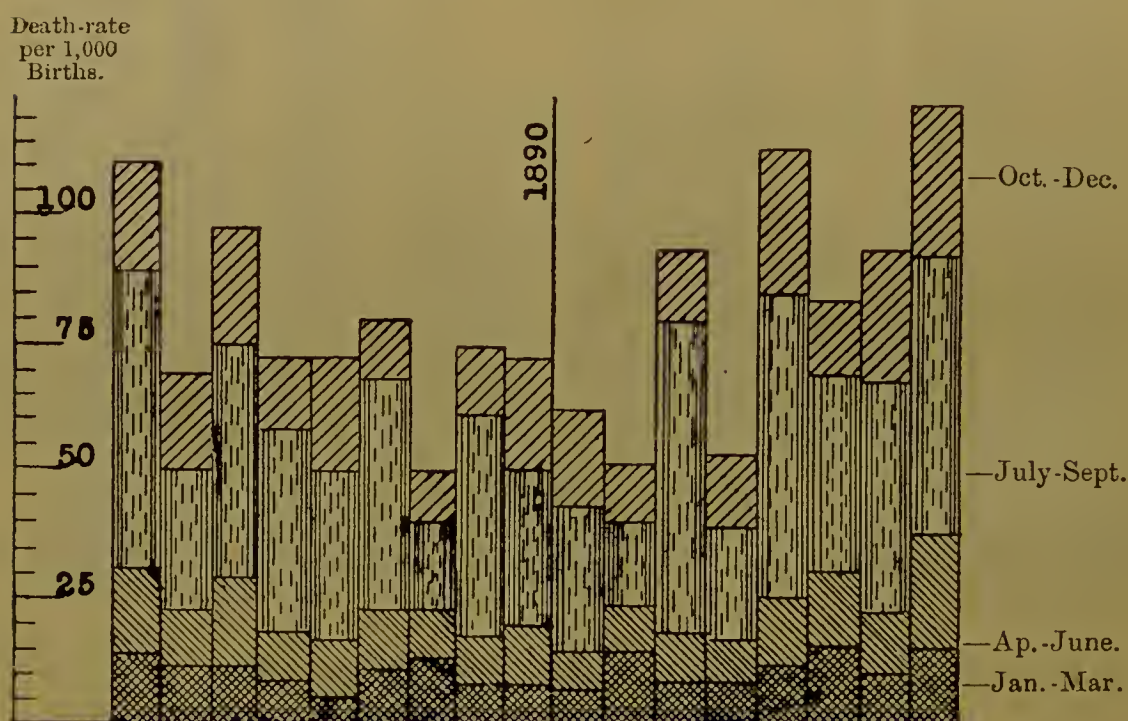
Fig. 6.—Edinburgh (1882-98).

Population estimated 1882 = 232,440.
,,   ,,   1898 = 295,628.

so steep as the above. In the older and less sanitary parts of the town the gradients are very steep.—*Dr. H. Littlejohn.*

Conservancy System.—Water-closets are almost universal.

Course of Diarrhœa.—The average annual death-rate, 1882-98, was 20·9, in the third quarter 42·2, per 1,000 births. The mortality in the lowest (first) forms 25 per cent. of that in the highest (third)

quarter of the year. For the first quarter it occupies the twenty-eighth, for the second the twenty-third, for the third the second, and for the fourth quarter the twenty-first, place among the towns in Table D. It is clear that there is an excess of præ-epidemic and post-epidemic diarrhœa, and that in respect of epidemic diarrhœa only Halifax has so small an amount among the thirty-one towns in Tables C and D. A slight deterioration *re* diarrhœa is indicated in the diagram.

Plymouth.

Physiography.—It stands upon the slate and limestone of the middle Devonian series. The limestone rocks are compact in themselves, but broken by joints and fissures. The slate and rocks vary
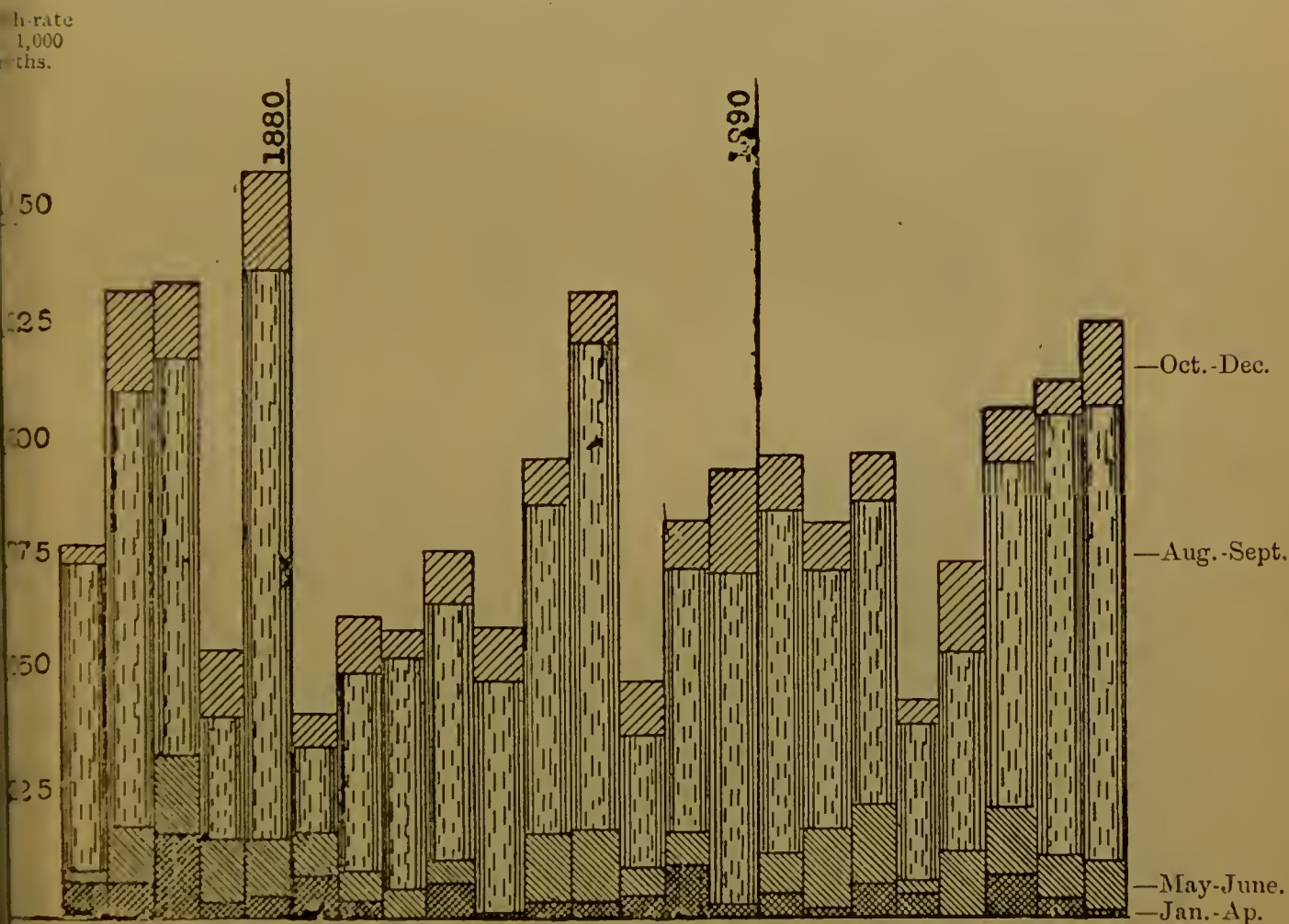
Fig. 7.—Plymouth (1876-98).

Population estimated 1876 = 72,230.
      ,,   ,,   1898 = 99,136.

considerably in character, from the loose broken material, locally known as "shillet," to the compact red and purple slates. As a rule, however, the slate rocks admit freely of percolation. The gradients are not very great, the highest point, a portion of a

recently-added area, being 200 feet above sea-level, and the slope being gradual towards the sea.—*Dr. Williams, Annual Report*, 1898.

Course of Diarrhœa.—The average annual death-rate, 1882-98, was 22·3, in the third quarter 64·7, per 1,000 births. The mortality in the lowest (first) forms 6 per cent. of that in the highest (third) quarter of the year. For the first quarter it occupies the third, for the second the fourteenth, for the third the eighth, and for the fourth quarter the sixth, place among the great towns in Table C. The condition of Plymouth has remained fairly stationary throughout the period embraced by the diagram.

Newcastle-upon-Tyne.

Physiography.—It is situate entirely on the coal-measures. The greater part of the drift is boulder clay, with occasional glacial gravel and pebble beds. The gradients in the city are good.
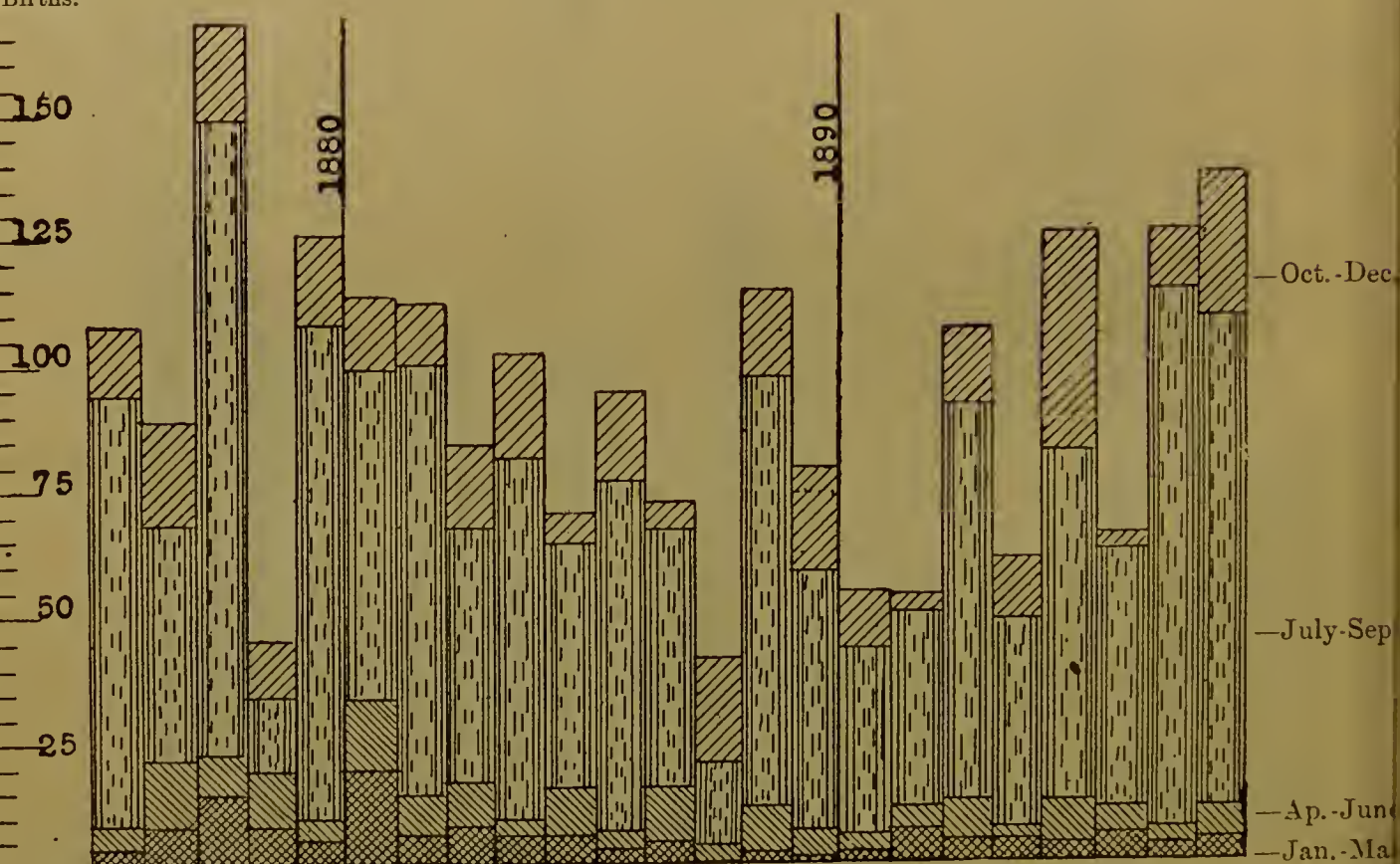
Fig. 8.—Newcastle-upon-Tyne (1876-98).

Population estimated 1876=139,929.
„   „   1898=223,021.

Conservancy System.—5,346 pail-closets in 1897, as compared with 2,535 in 1888, 2,730 privy middens in 1897, as compared with 6,047 in 1888, also a preponderant number of w.c.'s.—*Dr. Armstrong, Annual Report*, 1898.

Course of Diarrhœa.—The average annual death-rate, 1882-98, was 22·4, in the third quarter 62·8, per 1,000 births. The mortality in the lowest (first) was 7 per cent. of that in the highest (third) quarter of the year. For the first quarter Newcastle occupies the eighth, for the second quarter the fourth, for the third quarter the seventh, and for the fourth quarter the thirteenth, place among the thirty-one towns in Table C. The amount of præ-epidemic diarrhœa is comparatively small. The city has remained about stationary *re* diarrhœa. Its experience in 1879 and in 1888 may be compared advantageously with that of other towns.

Derby.

Physiography.—Dr. Howarth, M.O.H., states: In the Valley of the Derwent the formation is alluvium; on each side of the valley

Death-rate per 1,000 Births.

175

150

125

100

75

50

25

1890

—Oct.-Dec.

—July-Sept.

—Ap.-June.

—Jan.-Mar.
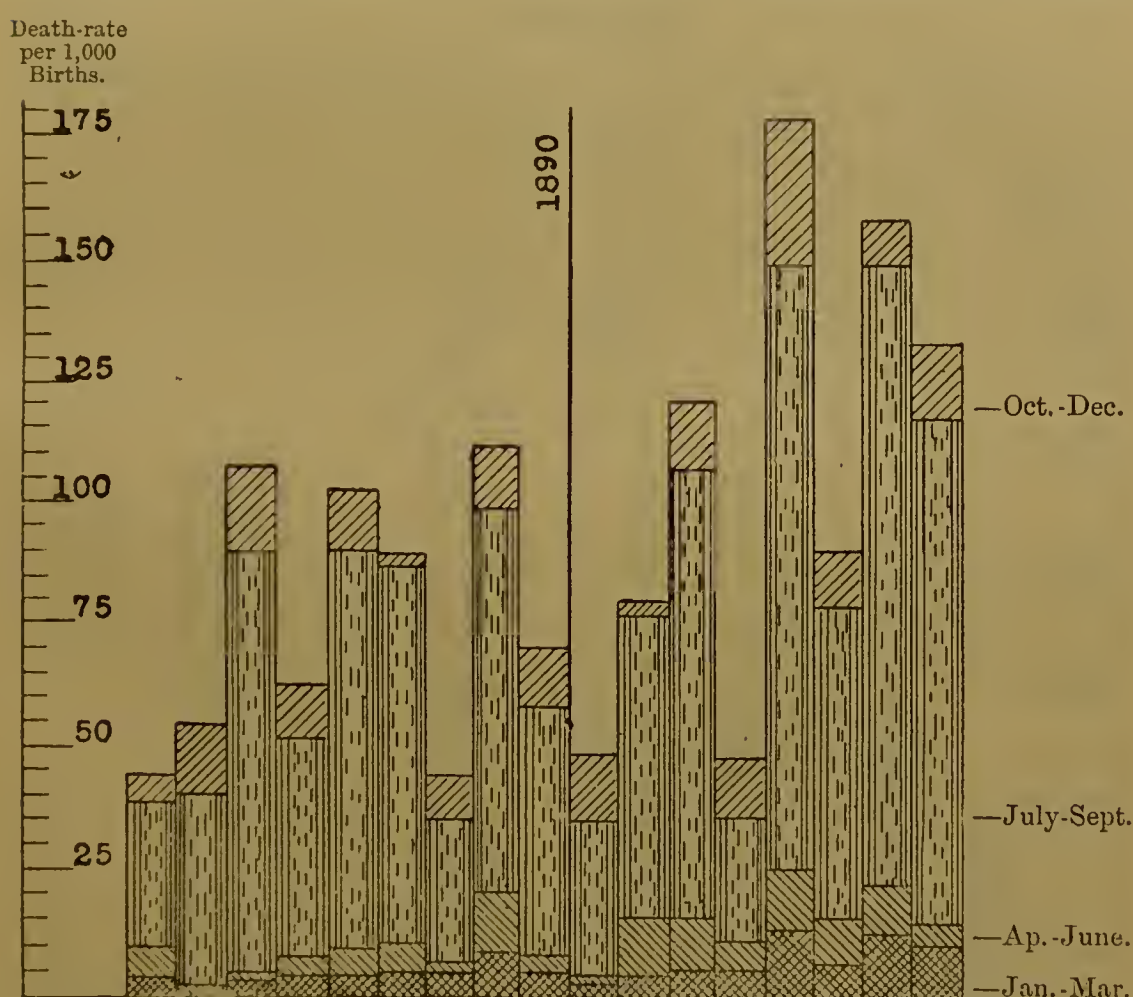
FIG. 9.—DERBY (1882-98).

Population estimated 1882 = 83,587.
　　　,,　　　　,,　　　1898 = 104,834.

are the upper Keuper series of rocks, overlying which is a red marl. There is a limited amount of sandstone in places. With the exception of the valley, the whole town is practically on the same

kind of soil. The gradients are variable, the highest point of the borough being 325 feet, and the lowest 142 feet, above sea-level.

Conservancy System.—There were in 1894 7,275 midden privies, 4,777 pails, 7,520 w.c.'s, and 318 trough-closets. A gradual conversion of privies is going on, 129 being changed into w.c.'s in 1898.

Course of Diarrhœa.—The average annual death-rate, 1882-98, was 22·6, in the third quarter 67·2, per 1,000 births. The mortality in the lowest (first) forms 8 per cent. of that in the highest (third) quarter of the year. For the first quarter it occupies the fourteenth, for the second the third, for the third the ninth, and for the fourth the seventh, place among the towns in Table C. The diarrhœa is chiefly of the epidemic type, and the town has somewhat deteriorated during the time under observation.

Birkenhead.

Physiography.—The ground is fairly flat towards the east or river side of the town, rising gradually westward to a height of 230 feet
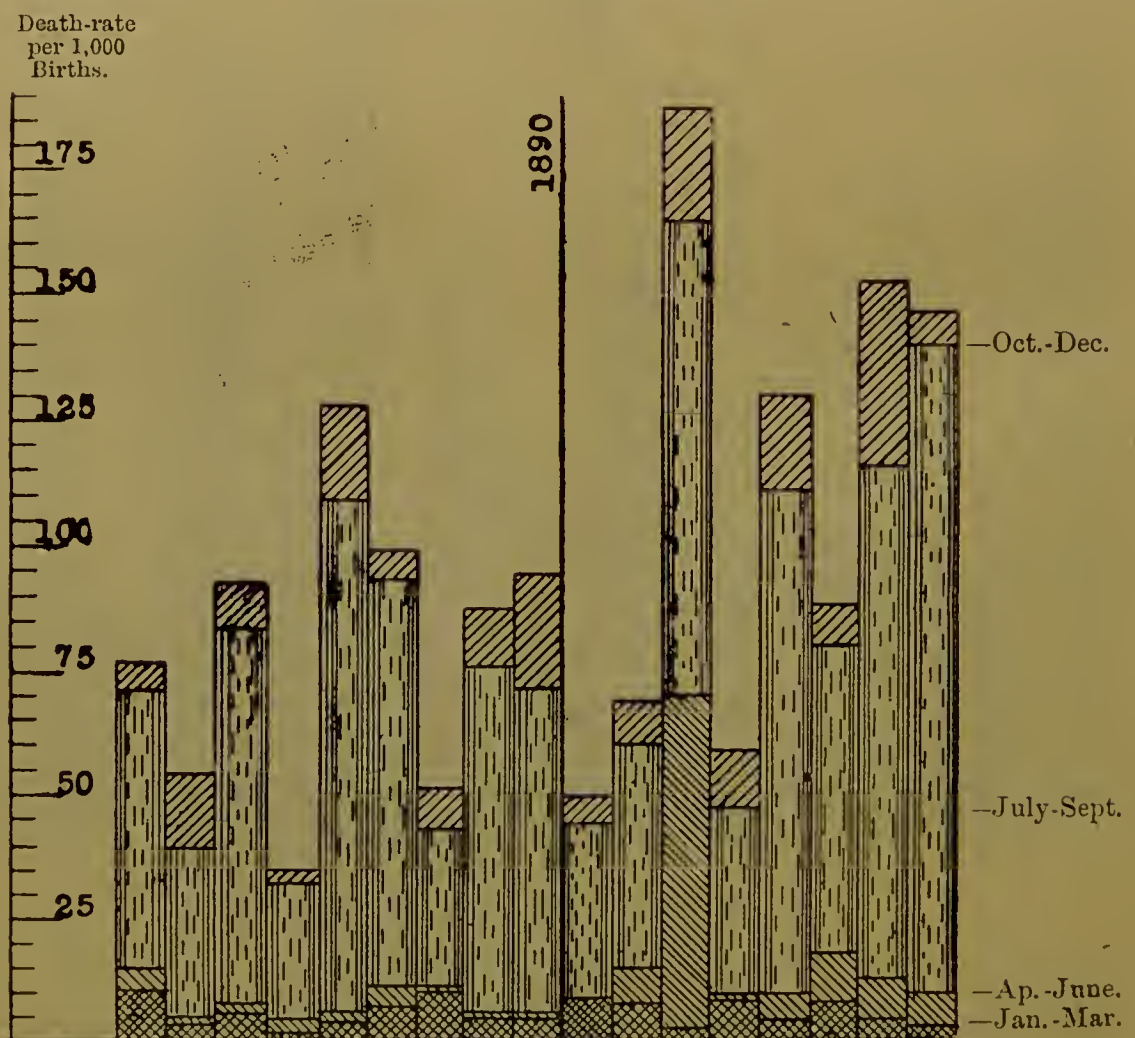
FIG. 10.—BIRKENHEAD (1882-98).

Population estimated 1882 = 86,582.
,,   ,,   1898 = 113,189.

above Ordnance datum. The district is chiefly on sand, on the top of Keuper rock, with faults here and there of boulder clay upon pebble-beds. Underlying the whole is a stratum of red sandstone at a considerable depth, from which the water-supply is obtained.—*Dr. Marsden, M.O.H.*

Conservancy Arrangements.—In 1899 there are 500 midden privies, mostly in the outlying parts of the borough, and 20,000 w.c.'s.—*Dr. Marsden.*

Course of Diarrhoea.—The average annual death-rate, 1882-98, was 23·2, in the third quarter 68·6, per 1,000 births. The mortality in the lowest (first) forms 8 per cent. of that in the highest (third) quarter of the year. For the first quarter it occupies the fifteenth, for the second the eleventh, for the third the twelfth, and for the fourth quarter the third, place among the towns in Table C. The diarrhoea is chiefly of the epidemic type, and the town has deteriorated in regard to this disease.

London.

Physiography.—The subsoils of London are complex, and it is impossible to state the proportion of population living on pervious and impervious strata. Along the banks of the Thames there is considerable alluvium. A large part of old London and the villages now compacted in modern London were built on tracts of valley gravel and loam, the loam or brick-earth forming a practically impervious covering over a considerable portion of the gravel. The greatest extension of modern London has been on to impervious clay, branching out from the old gravel-beds, from which well-water was obtainable. (For details see " Soils and Subsoils," by H. B. Woodward, F.R.S. : " Memoirs of the Geological Survey," 1897, 2s. 6d.)

Conservancy System.—Almost entirely water-carriage.

Course of Diarrhoea.—The average annual death-rate, 1882-98, was 23·3, in the third quarter 70·8, per 1,000 births. The mortality in the lowest (first) formed 7 per cent. of that in the highest (third) quarter of the year. For the first quarter London occupies the ninth, for the second the eleventh, for the third the thirteenth, and for the fourth quarter the first, place among the thirty-one towns in Table C. London occupies a fairly stationary position as regards total annual diarrhoea.

In view of the fact that London is rather a province of houses than a single town, it becomes necessary to study the incidence of diarrhoea within it in further detail. For this purpose, in order to obtain a sufficiently long series of years, it has been necessary to take registration and not sanitary districts ; and no attempt has

been made to state separately the diarrhœal death-rate for each quarter of the year. The diagrams relating to the thirty registration districts of London are not given here, from considerations of space and expense. In the absence of diagrams it is difficult to bring out the salient features of the diarrhœal mortality of London, and only a few can be indicated. The figures deal with the years 1891-98 inclusive.

Of the *western districts*, Westminster occupies the best position. St. George, Hanover Square, is a bad second; Paddington and Kensington come third; while Fulham and Chelsea are fourth in order of increasing mortality. It would be interesting to know what
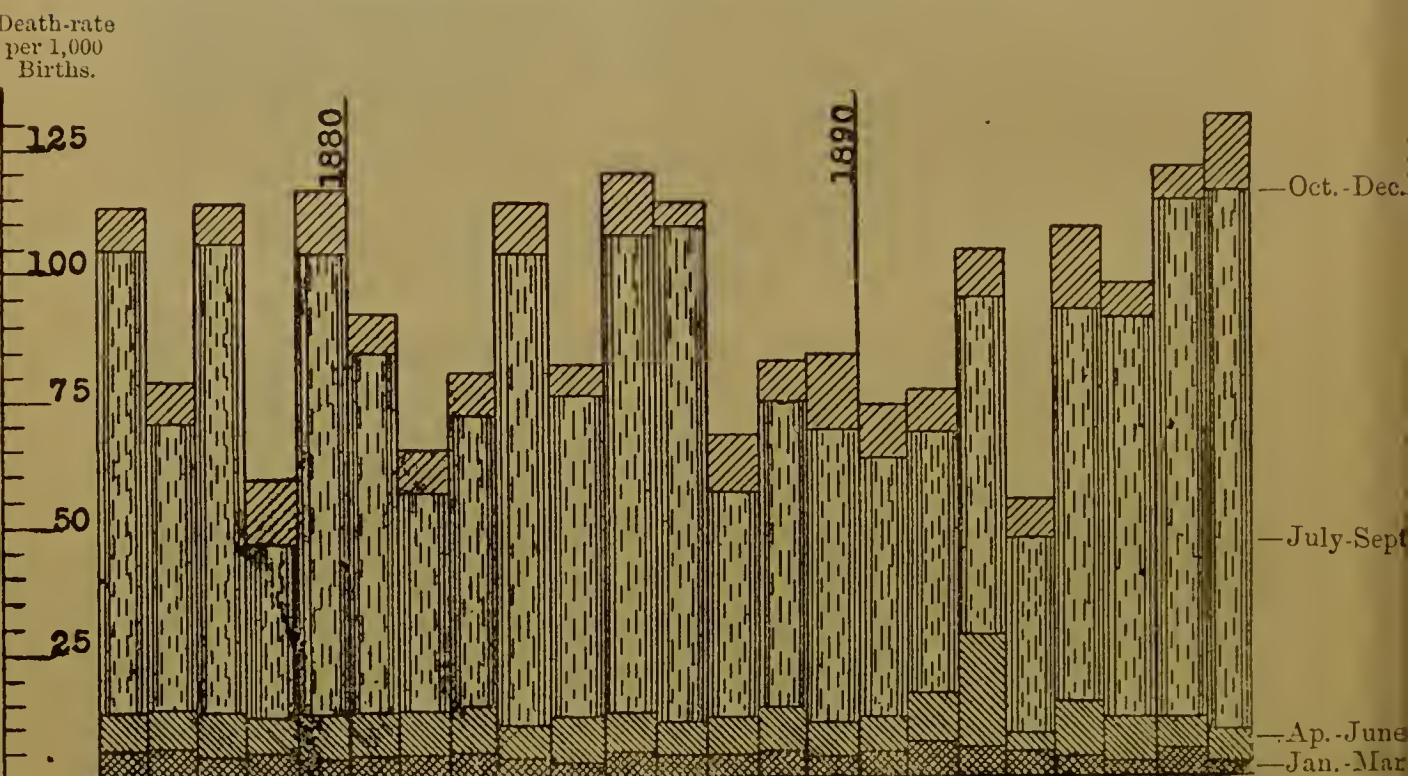
Fig. 11.—London (1876-98).

Population estimated 1876=3,537,314.
         ,,   ,,   1898=4,504,766.

local conditions (milk-supply, local scavenging, or other) caused Fulham to suffer more in 1898 than in 1897, while all the other western districts (except Westminster) showed a decrease.

St. Giles is the best of the *central districts*. The City is a poor second. Holborn comes next. The steady and uninterrupted increase in the four years 1895-98 requires explanation, and the even more rapid increase in the Strand district is remarkable.

Of the five *northern districts* Hampstead occupies the premier position, but Marylebone is a good second. Hackney and St. Pancras follow close after Islington. There are curious differences among the three last-named districts. The year 1896 was a very

bad year for Hackney. It reached its maximum for diarrhœa in that year, there being a slight improvement in 1897 and 1898. On the other hand, in St. Pancras there was less diarrhœa in 1896 than in 1895 or 1897-98 ; while Islington suffered a very striking increase in 1898 over the three preceding years. It is open to surmise that there are artificial differences caused by vagaries of death-certification ; but my opinion is that, after making free allowances for these, real differences are indicated by the above facts, which a full knowledge of facts of local experience and sanitary administration might enable us to explain.

The seven *eastern districts* show greater variations in diarrhœal mortality. Whitechapel has an extremely good record. Judging by the diagram (without calculating an average death-rate), it is only surpassed throughout London by Westminster. Is this due to an excessive proportion of Jew infants in the population ? Bethnal and Mile End make good seconds, whilst Poplar is but little worse. Shoreditch and St. George-in-the-East have a much larger amount of fatal diarrhœa. Stepney has an equal amount, and is further remarkable for the fact that in 1898 it had more than double the amount of diarrhœa in any preceding year. What special local circumstance accounted for this? The eastern districts show another peculiar difference among themselves. In Whitechapel and St. George-in-the-East there is much less variation in the yearly incidence of diarrhœa than in other districts.

St. Saviour's and St. Olave's, *Southwark*, have about an equal amount of total diarrhœa ; but in St. Saviour's the amounts in 1897 and 1898 were nearly equal, while in St. Olave's there was a great decline in 1898.

Of the more *southern districts* Woolwich has the best record, though its position is deteriorating. In Lewisham and Greenwich the 1897-98 incidence of diarrhœa was even greater. The amounts of diarrhœa in Lambeth, Camberwell, and Wandsworth were about equal.

Glasgow.

Physiography.—The following information, furnished by Professor Young, of Glasgow University, is forwarded by Dr. Chambers, the Medical Officer of Health of the City of Glasgow : From the river on either side stretches an alluvial flat of considerable depth. The horizontal stratification is interrupted only by drains and gas-pipes, but even without these artificial drainage lines the whole may be described as fairly dry ; there is no "retentive stratum" in it. "Rising from the level of George Square, the sand and gravel thin,

but it is only on the summit, as of Gilmorehill, that the boulder clay is actually at the surface. Even here there was a thin coating of sandy gravel (1865).

"Along Byres Road and Western Road the carboniferous strata come close to the surface, but their area does not give them importance; besides, their dip is enough to make them good drains. The Necropolis and its shoulders stand out of the boulder clay; passing east from it, you come upon the thin sandy soil thickening into the sand and gravel which cover the boulder clay all round Glasgow—one may say from the high ground back of
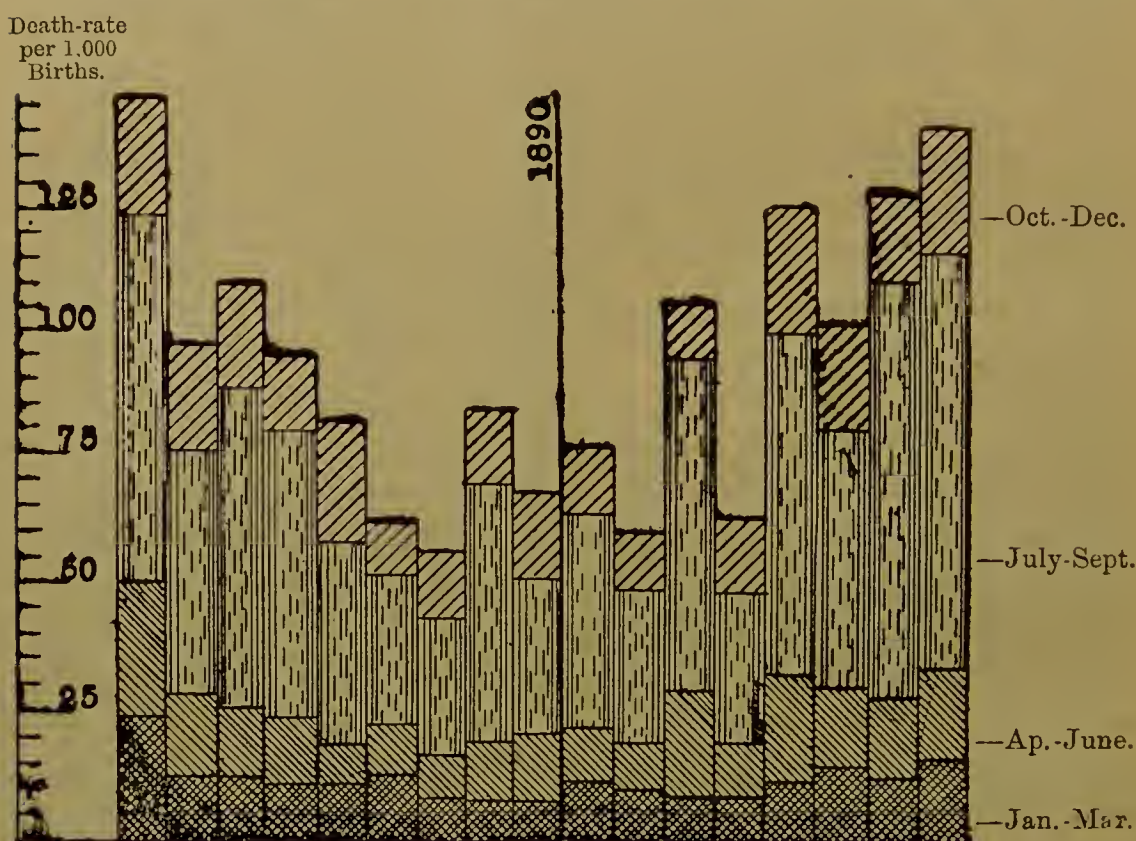
Fig. 12.—Glasgow (1882-98).

Population estimated 1882=514,048.
          ,,   ,,   1898=724,349.

Paisley across to Kirkintilloch, etc.—then the boulder clay at various depths. North to Springburn the boulder clay comes to the surface more extensively, and the rock is not far off; pass Springburn, and the sand and gravel resume.

"Surface geology medicine is recent, and I have not followed it closely, but in the case of Glasgow I do not think you will find in soil any determining cause. If the soil does anything in the medical line, it does the same thing over the district generally. For special manifestations in particular places, special local explorations might discover pool-like depressions of the boulder clay, or of the sand gravels—local swamps, in short. These are sometimes helped or

created by neglect of the Building Act, which bars 'free coups' as building sites for, I think, fourteen years. There have been districts of Glasgow copious in enteric disorders, in which old quarries figured, burns and cesspools contributing. Queen's Crescent I heard of forty years ago as a lucrative but unhealthy building locality, now, I suppose, above suspicion in this respect.

"What I mean is, there is so great uniformity of soil conditions on the south side and over the north in great part, that special manifestations are more likely to belong to local accidents or to point to human blunders."

Conservancy System.—Chiefly a w.c. town, w.c.'s having replaced in a large measure midden privies. Many w.c.'s are used in common by several tenants. Number of privies and pails unknown, but rapidly decreasing. Pails are scavenged daily.

Course of Diarrhœa.—The average annual death-rate, 1882-98, was 23·9, in the third quarter 51·7, per 1,000 births. The mortality in the lowest (first) formed 23 per cent. of that in the highest (third) quarter of the year. For the first quarter Glasgow occupies the twenty-ninth, for the second quarter the twenty-seventh, for the third quarter the sixth, and for the fourth quarter the eighteenth, place among the thirty-one towns in Table C. There is, on the whole, no improvement in the present condition of Glasgow *re* diarrhœa compared with its past experience. The total amount, however, is very small as compared with that in the large English cities. Another interesting feature is the excessive amount of præ-epidemic, and the very small amount of epidemic, diarrhœa. It shares this feature with Edinburgh, Bristol, and, to a less extent, with other towns. (See also page 10.)

Cardiff.

Physiography.—The southern half of the borough is on alluvial and marine clay, very impervious. The northern half is gravel. The clay is of great depth towards the docks and shore, thinning off towards the gravel. Underneath the clay is a gravel and sand bed of considerable thickness, which appears at the surface in the northern part of the borough. Underneath the gravel and clay are impervious strata of various kinds, carboniferous, old red sandstone, or silurian. Three rivers run through Cardiff into the Bristol Channel, the Taff through the centre, the river Romney forming the eastern, and the river Ely the western, boundary of the borough. The population in the southern part of the borough is more largely adult than that to the north.—*Letter from Dr. Walford, M.O.H.*

Conservancy System.—Entirely a w.c. town.

Course of Diarrhœa.—The average annual death-rate, 1882-98, was 24·6, in the third quarter 68·1, per 1,000 births. The mortality in the lowest (first) was 9 per cent. of that in the highest (third) quarter of the year. For the first quarter Cardiff occupied the sixteenth, for the second quarter the fifteenth, for the third quarter
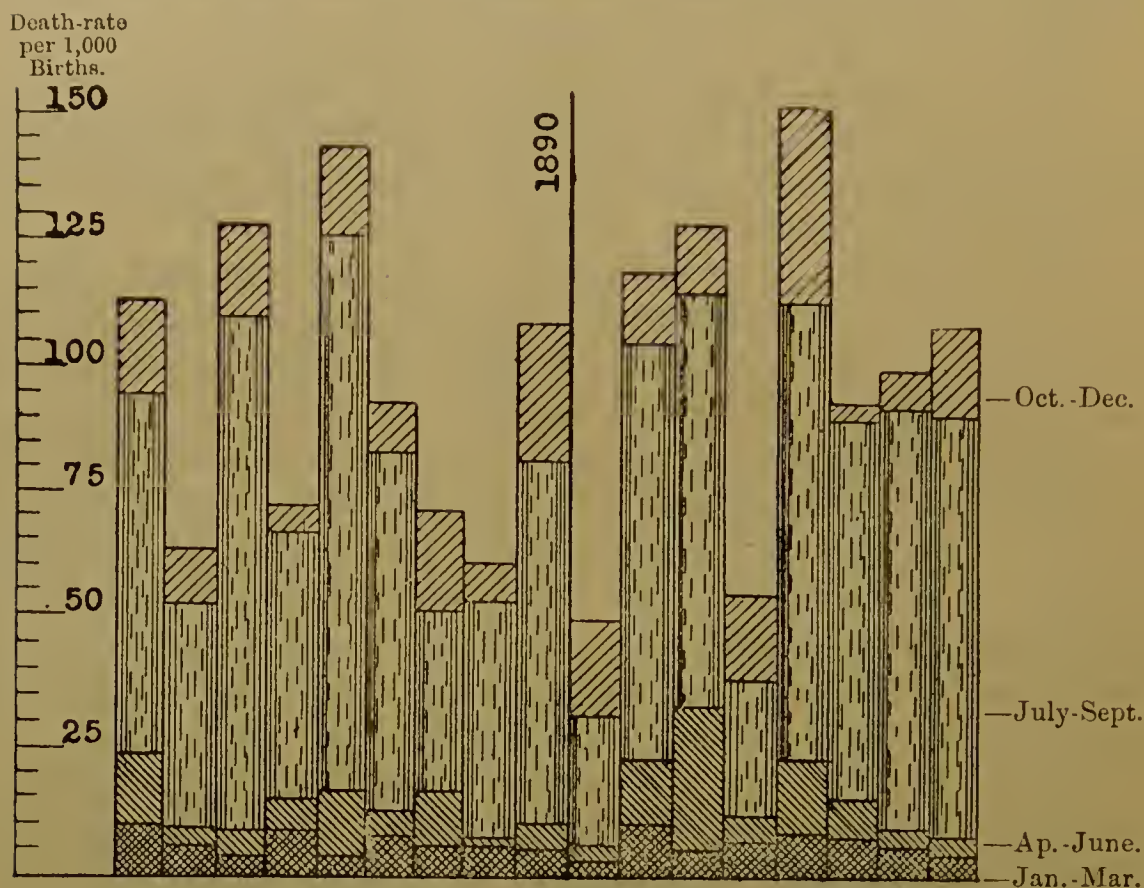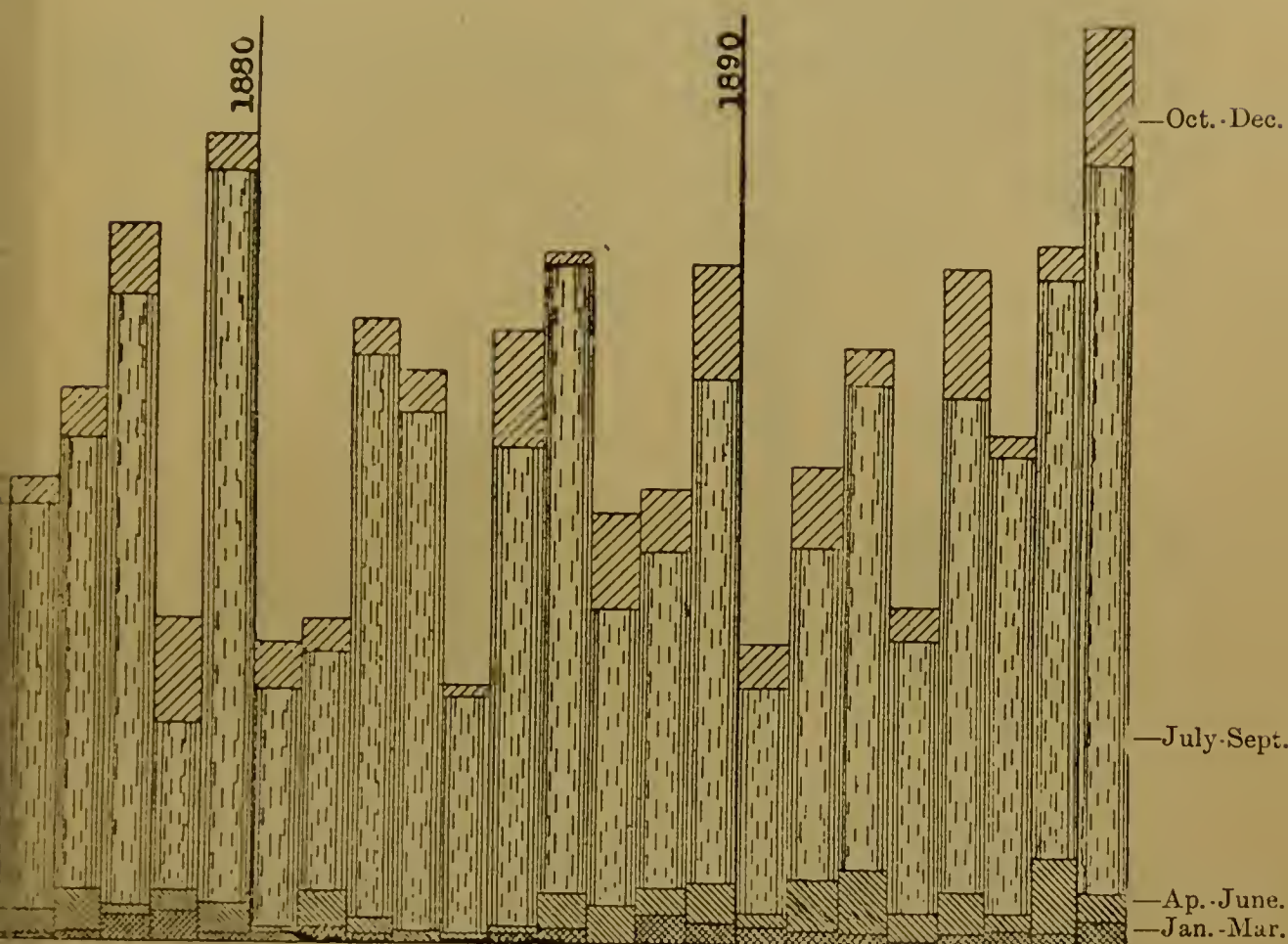

FIG. 13.—CARDIFF (1882-98).

Population estimated 1882= 86,724.
,,   ,,   1898=177,770.

the eleventh, and for the fourth quarter the eleventh, place among the thirty-one towns in Table C. The diarrhœal mortality has, if allowance be made for adverse meteorological conditions in recent years, probably slightly improved. Cardiff occupies a slightly more favourable position for epidemic than for præ- or post-epidemic diarrhœa.

Brighton.

Physiography.—Is built mainly on the pervious chalk, with coombe rock in the lower parts—*i.e.*, a mixture of flints and chalk, which is even more pervious than chalk. The subsoil water is very low. The town lies mainly on the steep slopes of two hills, and on somewhat less steep declivities sloping southward to the sea.

Conservancy System.—Entirely water-carriage. Every house is supplied with w.c.'s, and is drained to the main sewer. All cesspools have been abolished.

*Course of Diarrhœa.*—The average annual death-rate, 1882-98, was 27·6, for the third quarter 87·0, per 1,000 births. The mortality in the lowest (first) formed only 4 per cent. of that in the highest (third) quarter of the year. For the first quarter Brighton occupied

FIG. 14.—BRIGHTON (1876-98).

Population estimated 1876=100,632.
,,   ,,   1898=122,310.

the second (being surpassed by Norwich), for the second quarter the fifth, for the third quarter the fourteenth, and for the fourth quarter the ninth, place among the thirty-one towns in Table C. The diarrhœa is chiefly of the epidemic type.

Dublin.

Physiography.—Is built on boulder clay and limestone gravel. In 1891, 169,615 people lived on the clay, and 75,486 on the gravel. In the gravel the ground-water is from 14 to 18 feet below the surface of the ground, in the clay 5 to 6 feet only. The gravel lies near the river Liffey, which flows through the centre of the city, the clay occupying the higher parts of the city.—*Sir C. Cameron.*

4—2

Conservancy System.—Is almost entirely a w.c. town. Sir C. Cameron stated in his annual report for 1894 that until recently there existed in Dublin middens in large numbers, with consequent organic pollution of the soil, from the effects of which the soil has not yet had time to recover. Dublin is low-lying, the greater part of it being built upon a water-logged site, where the subsoil is only drained when the tide is out.

Course of Diarrhœa.—The average annual death-rate, 1882-98, was 28·1, in the third quarter 67·3, per 1,000 births. The mortality
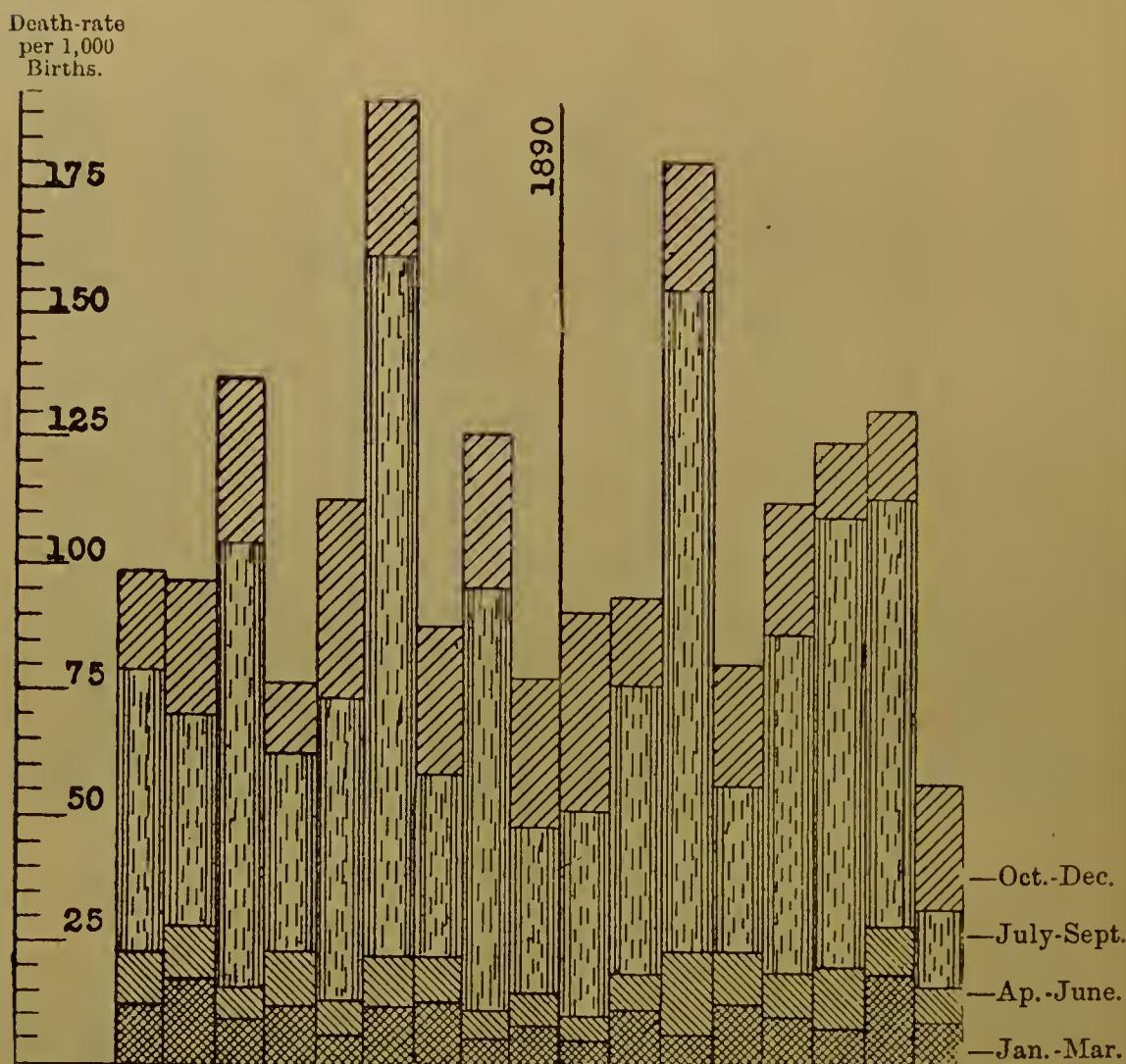
FIG. 15.—DUBLIN (1882-98).

Population estimated 1882 = 348,293.
„   „   1898 = 345,594.

in the lowest (first) forms 14 per cent. of that in the highest (third) quarter of the year. For the first quarter it occupies the twenty-sixth, for the second the twentieth, for the third the tenth, and for the fourth quarter the twenty-eighth, place among the thirty-one towns in Table C. If 1898, which was curiously low, be excluded, the diarrhœal death-rate may be regarded as almost stationary. It

is among the towns with a large proportional amount of endemic diarrhœa, the amount of post-epidemic diarrhœa being particularly high.

Portsmouth.

Physiography.—Is chiefly built on gravel, and the greater part only 15 feet above sea-level. Is very flat. Here and there are stretches of loam, but this is so thin that the foundations of the houses are on the gravel. The subsoil water is only a few feet from the surface.

Conservancy System.—Nearly all the houses have w.c.'s. A large number of these are without efficient flushing-cisterns.
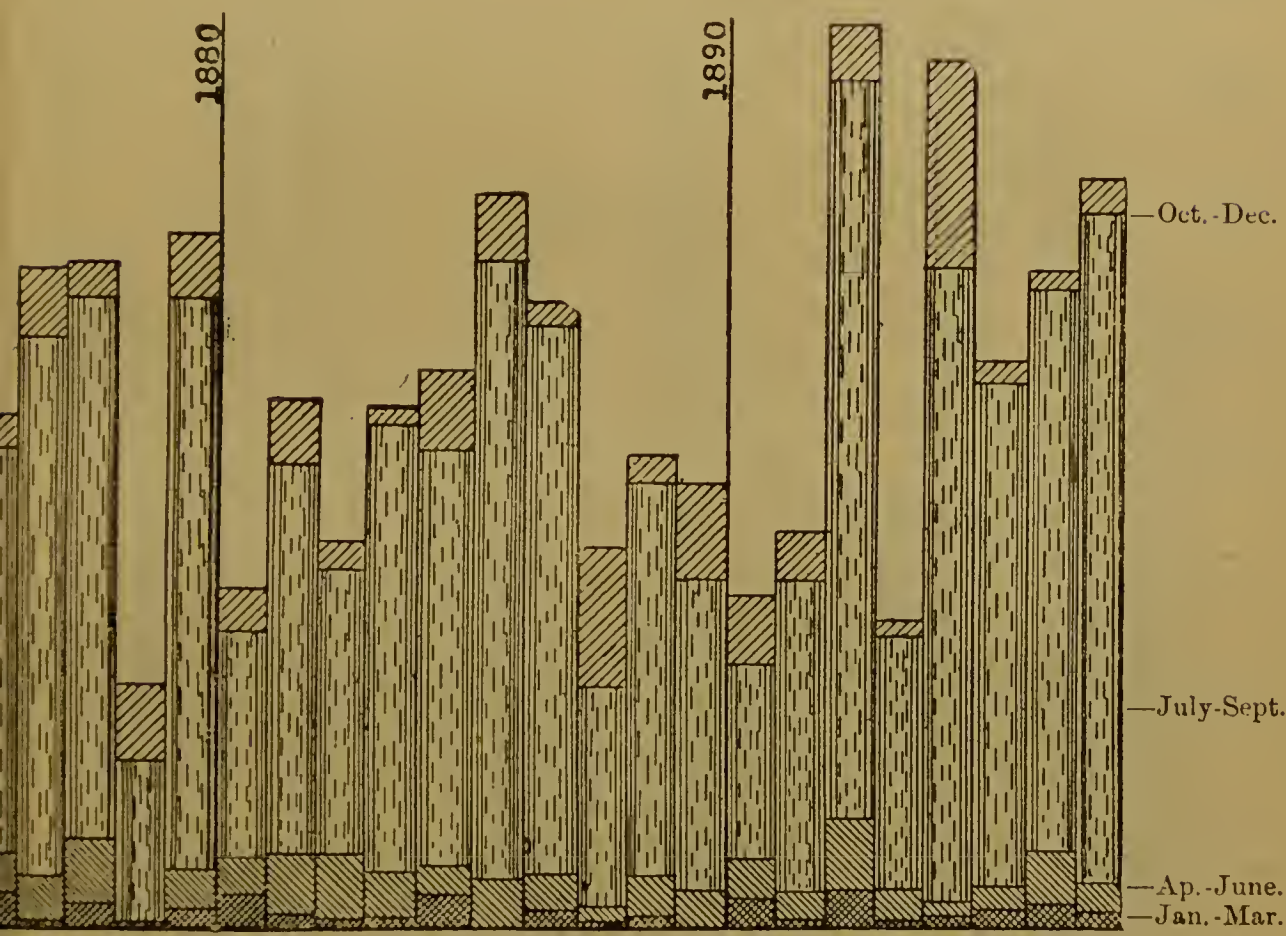
Fig. 16.—Portsmouth (1876-98).

Population estimated 1876 = 124,867.
,,   ,,   1898 = 186,618.

Course of Diarrhœa.—The average annual death-rate, 1882-98, was 31·4, in the third quarter 102·0, per 1,000 births. The mortality in the lowest (first) formed 4 per cent. of that in the highest (third) quarter of the year. For the first quarter Portsmouth occupies the fourth, for the second the ninth, for the third the nineteenth, and for the fourth quarter the fifth, place among the thirty-one towns

enumerated on page 9. The amount of diarrhœa has remained about stationary during the period embraced in the chart. The diarrhœa is chiefly of the epidemic type.

Sunderland.

Physiography.—The subsoil consists of an impervious layer of boulder clay, varying from a few feet to 100 feet in depth. This clay, as a rule, is simply covered by a layer of clayey soil, but in
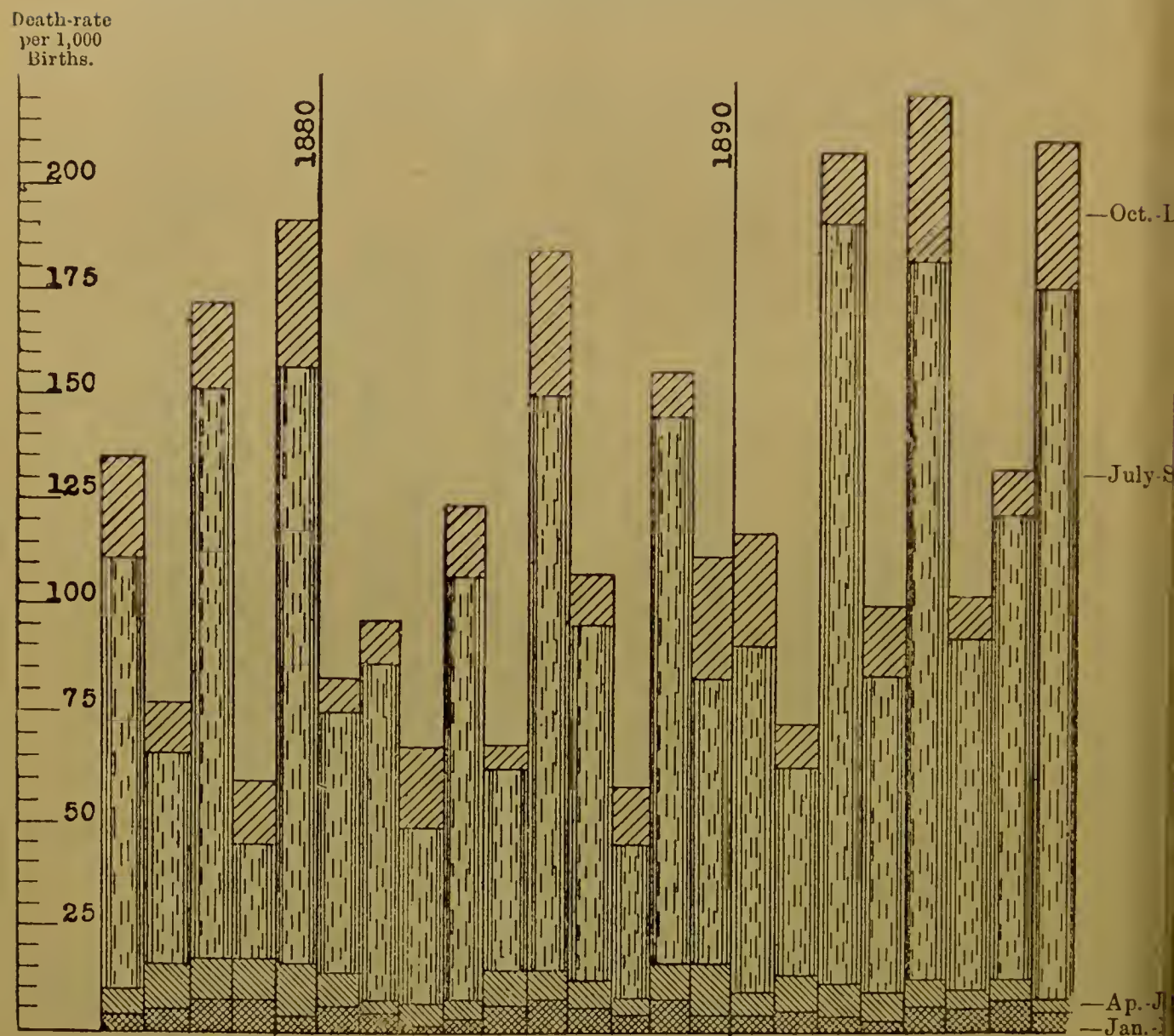
FIG. 17.—SUNDERLAND (1876-98).

Population estimated 1876 = 108,343.
                     „   „   1898 = 143,849.

certain parts of the district, over limited areas, beds of sand or gravel overlie the clay. Monkwearmouth is situated on one of these sand or gravel beds, and it shows the greatest mortality from diarrhœa and enteritis. The gradients are slight, the town being chiefly built on a flat plain.—*Dr. Scurfield, Annual Report,* 1897.

Conservancy System.—2,760 houses have w.c.'s only, 850 of these with privies and ashpits; 425 have w.c.'s with ash-closets; 11,160 have privies and ashpits, 4,660 ash-closets, and 800 pan-closets, and 75 no conveniences at all.—*Dr. Scurfield, Annual Report*, 1898.

Course of Diarrhœa.—The average annual death-rate, 1882-98, was 31·7, in the third quarter 97·0, per 1,000 births. The mortality in the lowest (first) forms 5 per cent. of that in the highest (third) quarter of the year. For the first quarter of the year it occupies the seventh, for the second the sixth, for the third the seventeenth, and for the fourth quarter the twentieth, place among the thirty-one towns in Table C. It occupies a good position so far as the first and second quarters of the year are concerned, but a bad position for the third quarter, the amount in this quarter having increased in recent years. It is among the towns especially susceptible to the conditions producing epidemic diarrhœa, as evidenced by the high peaks in the diagram.

Norwich.

Physiography.—The higher levels in the city are made up of glacial gravels, through which the valleys have been excavated, exposing at their margins the crag formation and chalk, while gravel and alluvial deposit occupy the lower ground. The chalk, which at Norwich is over 1,000 feet thick, and underlies the whole of the city, comes to the surface in several places within the city, and may be reached at no great depth at all parts of the municipal area. —*Dr. Pattin, Annual Report*, 1897. The gradients are good. The soil is generally pervious. One-fifth of the population are on the low-lying alluvium, with subsoil water about 3 feet from the surface, the rest on the chalk on gradients which are good.

Conservancy System.—About 25 per cent. of houses have w.c.'s, rather over 25 per cent. have pail-closets, and the remainder "bins" or middens.

Course of Diarrhœa.—The average annual death-rate, 1882-98, was 32·4, in the third quarter 103·0, per 1,000 births. The mortality in the lowest (first) forms only 3 per cent. of that in the highest (third) quarter of the year. For the first quarter of the year it occupies the first, for the second the seventh, for the third the twenty-second, and for the fourth quarter the fourteenth, place among the thirty-one towns in Table C.

There is very little præ-epidemic diarrhœa. The amount of epidemic diarrhœa is great, and subject to violent increases, as in 1880, 1884, and 1886. There has been some improvement, the
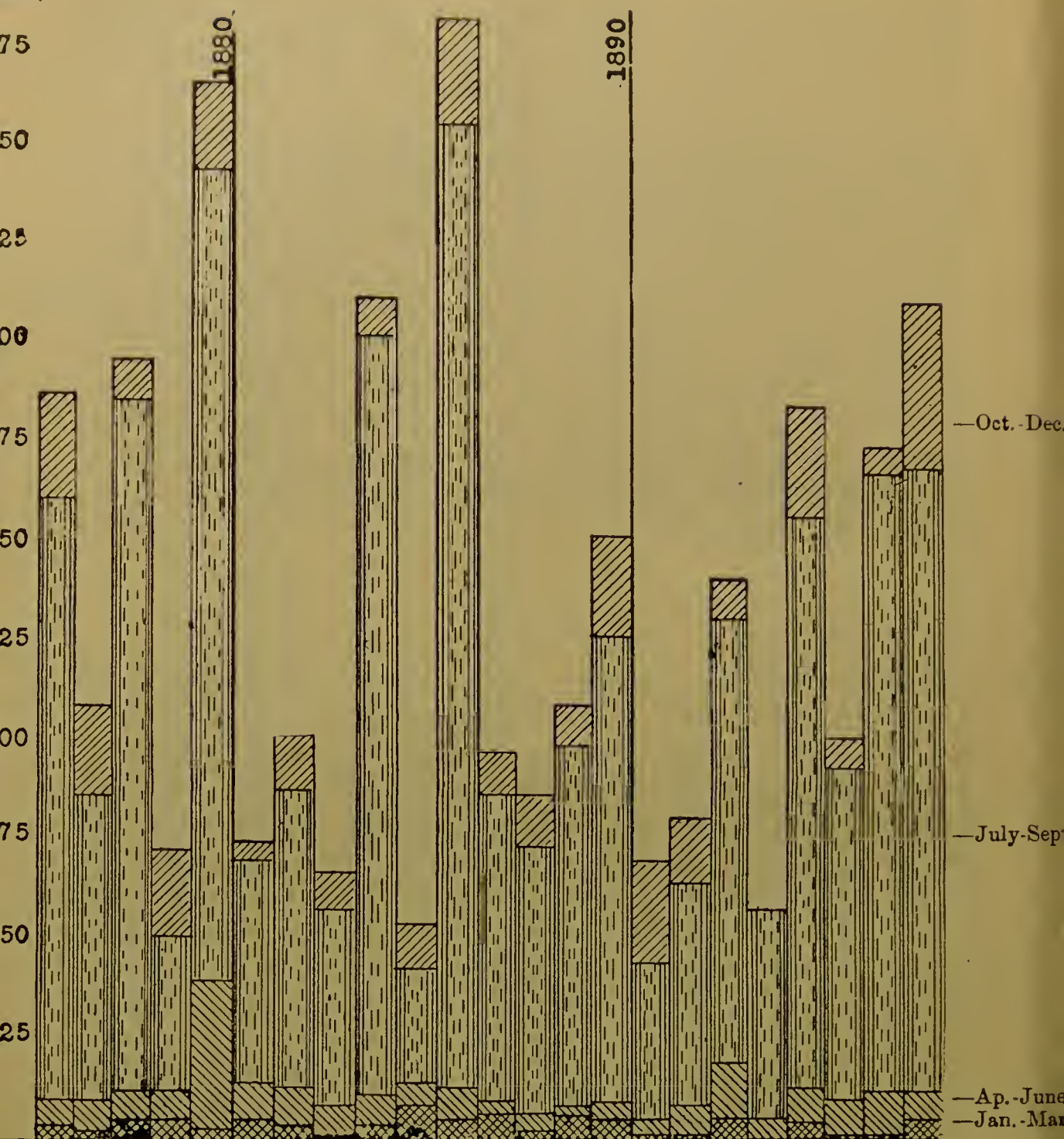
FIG. 18.—NORWICH (1876-98).

Population estimated 1876 = 83,430.
           ,,   ,,   1898 = 111,699.

recent hot summers not having been so productive of diarrhœa as similar summers in the past.   (See remarks on page 10 *et seq.*)

Manchester.

Physiography.—The greatest part of Manchester is built upon marl, a mixture of sand, gravel and clay, overlying the new red sandstone.

The information on page 7, furnished by Dr. Niven, gives more detailed information.

Conservancy System.—There are in the city pail-closets, 76,663 ; ash-boxes, 56,824 ; midden privies, 22,935 ; wet middens, 12,161 ;
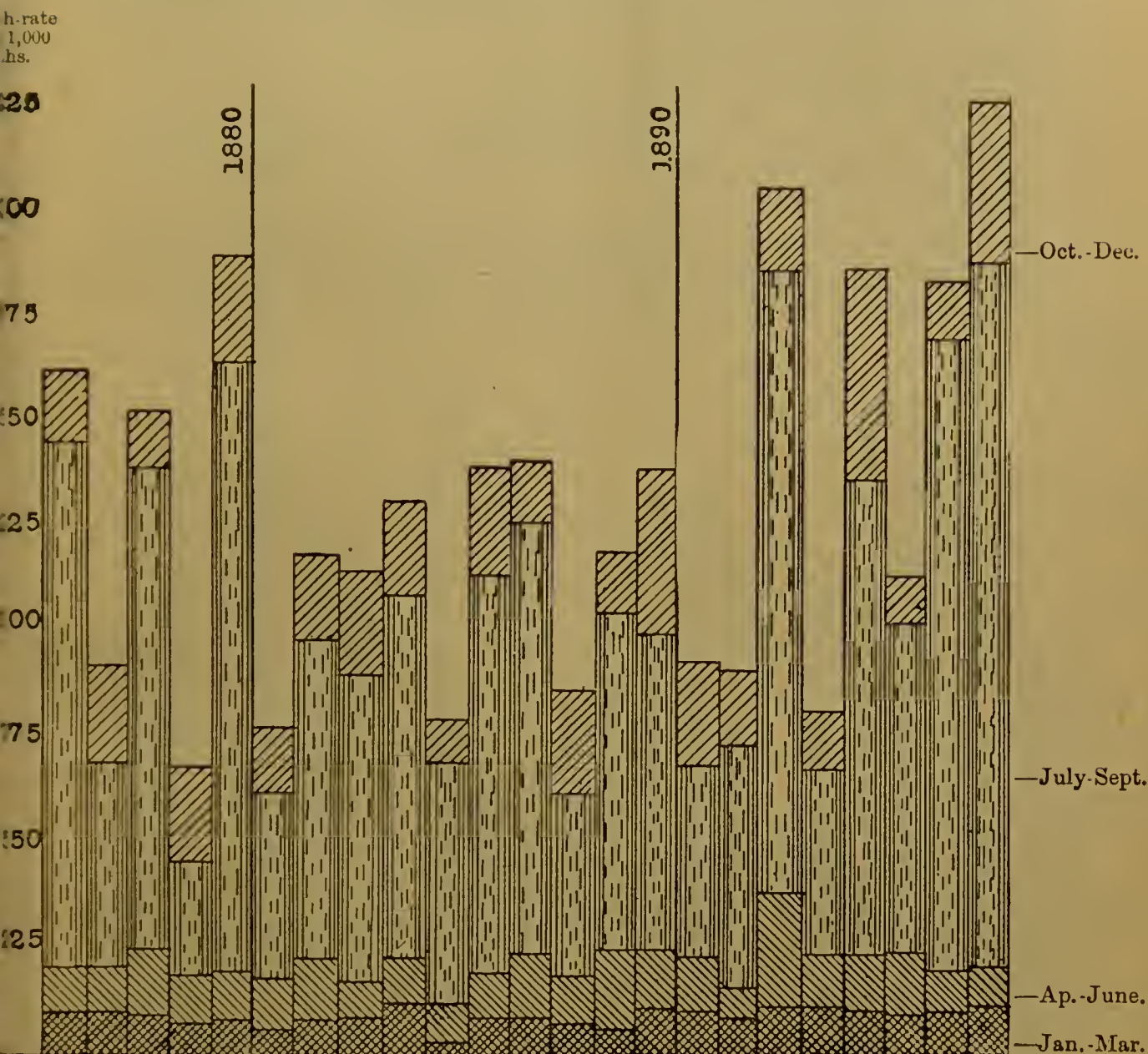
Fig. 19.—Manchester (1876-98).

Population estimated 1876 = 357,917.
     ,,   ,,   1898 = 539,079.

dry-middens, 743 ; water-closets, 35,807 ; and cesspools, 90.—*Dr. Niven, Annual Report*, 1898.

Course of Diarrhœa.—The average annual death-rate, 1882-98, was 32·7, in the third quarter 88·0, per 1,000 births. The mortality in the lowest (first) forms 10 per cent. of that in the highest (third) quarter of the year. For the first quarter it occupies the twenty-fourth, for the second the twenty-sixth, for the third the fifteenth, and for

the fourth quarter the twenty-fifth, place among the thirty-one towns in Table C. There is thus a large proportion of endemic diarrhœa in the city, the position of which is much better for the third than for other quarters of the year. The diagram indicates that Manchester has deteriorated in reference to diarrhœa, particularly diarrhœa of the epidemic type.

Nottingham.

Physiography.—Is situated on an acclivity of new red sandstone, rising from the river Trent.

Conservancy System.—In 1898 about 40,000 pails were in use, also a few privies, and probably 9,000 to 10,000 w.c.'s.
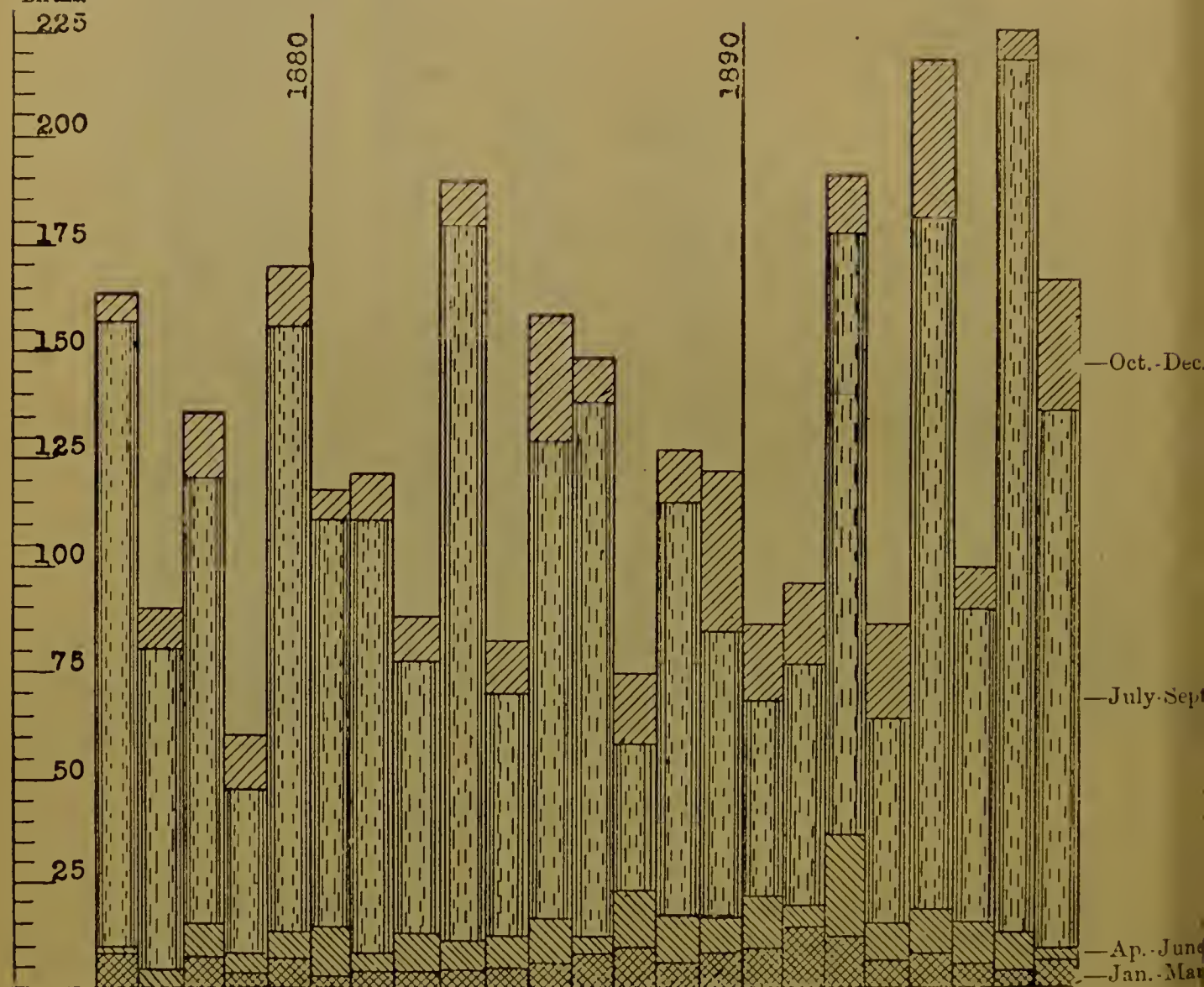
Fig. 20.—Nottingham (1876-98).
Population estimated 1876 = 93,627.
„   „   1898 = 236,137.

Course of Diarrhœa.—The average annual death-rate, 1882-98, was 33·9, in the third quarter 102·0, per 1,000 births. The mortality

in the lowest (first) forms 7 per cent. of that in the highest (third) quarter of the year. For the first quarter of the year it occupies the twentieth, for the second the nineteenth, for the third the nineteenth, and for the fourth quarter the sixteenth, place among the thirty-one towns in Table C. There is an excess of diarrhœa both of the epidemic and inter-epidemic type. Nottingham is, as evidenced by the height of the peaks in the diagram, very susceptible to epidemic diarrhœa. In total diarrhœa it has slightly deteriorated in the course of the diagram.

Bradford.

Physiography.—Bradford is situated on the lower coal-measures or ganister beds, with sandstone (Elland flagstone) in places. The
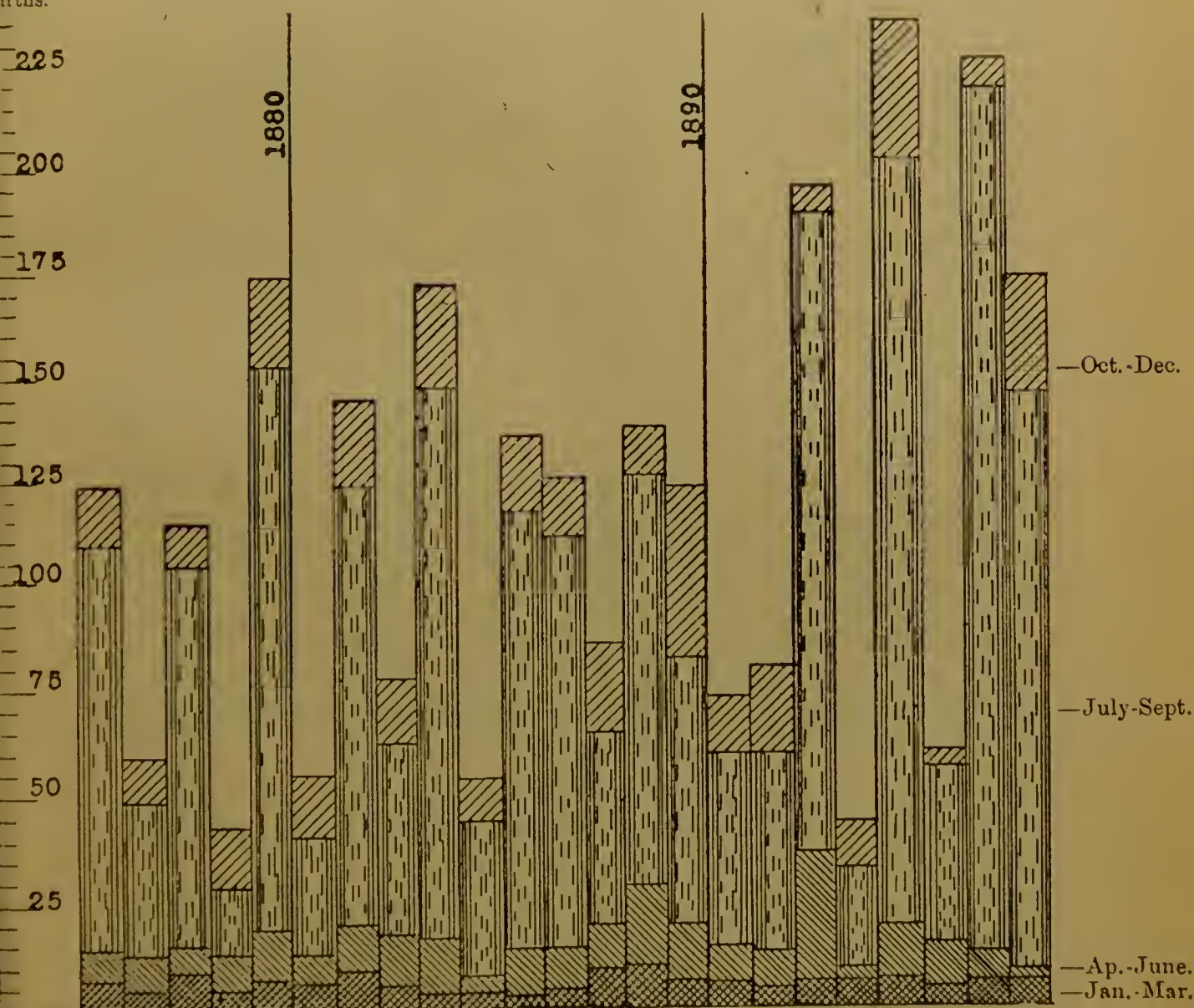
FIG. 21.—BRADFORD (1876-98).

Population estimated 1876=173,723.
          ,,   ,,   1898=233,737.

basin-shaped hollow, in the centre of which the town stands, is well-nigh covered by a thick deposit of boulder clay, containing numerous sub-angular stones. The clay is bluish, non-laminated, and very tough. The enclosed parts are derived from the grits and limestones of the northern part of the Aire Valley. In the district supplied by the Bradford waterworks the altitude ranges from 200 to 1,200 feet above sea-level, with a population of 365,000.

Conservancy System.—In 1894 there were 30,000 midden privies, 10,000 w.c.'s, and 500 waste-water closets.

Course of Diarrhœa.—The average annual death-rate, 1882-98, was 34·2, in the third quarter 98·9, per 1,000 births. The mortality in the lowest (first) forms 7 per cent. of that in the highest (third) quarter of the year. For the first quarter it occupies the eighteenth, for the second the twenty-second, for the third the eighteenth, and for the fourth quarter the twenty-second, place among the towns in Table C. The diagram indicates a deterioration *re* diarrhœa. There are acute variations in its annual incidence, Bradford being evidently among the towns susceptible to the epidemic type of diarrhœa.

Leeds.

Physiography.—For the following description I am indebted to Dr. Spottiswoode Cameron : " Leeds is situated chiefly upon the ganister coal-fields, some portions of which are worked within the boundaries of the borough. The general tendency of the faults is to run from east to west. One important fault, a little to the north of the centre of the town, throws up the sandstone (Elland edge) that lies underneath the coal-beds. North of this another important fault runs from about north-east by east to about south-west by west. This throws up the millstone grit to the level of the Elland flags. Through the very centre of the town, from north-west to south-east, runs the river, and two important tributaries—the Hol Beck on the south, and the Meanwood Beck on the north—join the river within about half a mile of one another. They have contributed to make a somewhat considerable mass of alluvium along the course of the river and to the south of it. With this exception the subsoil is either sandstone, shale, or clay. The latter predominates throughout the town at the surface.

" The bed of the river has only a very gentle inclination, but the ground rises considerably to the north and to the south-west. Underneath, between the Elland flagstone and the Thornhill rock, although there are a few intrusions of sandstone, the layers are chiefly clay and shale. Such sandstones as lie between these rocks are somewhat of a raggy nature, and a good deal that is coloured

as sandstone in the geological map is really of this nature. The greater part of the most populous part of the town—the three divisions west, north, and south-east of the Leeds township—lie almost entirely on shale or clay. This clay or shale is covered by the alluvium already referred to in a portion of the centre of the town. I should regard the soil of Leeds as on the whole retentive of
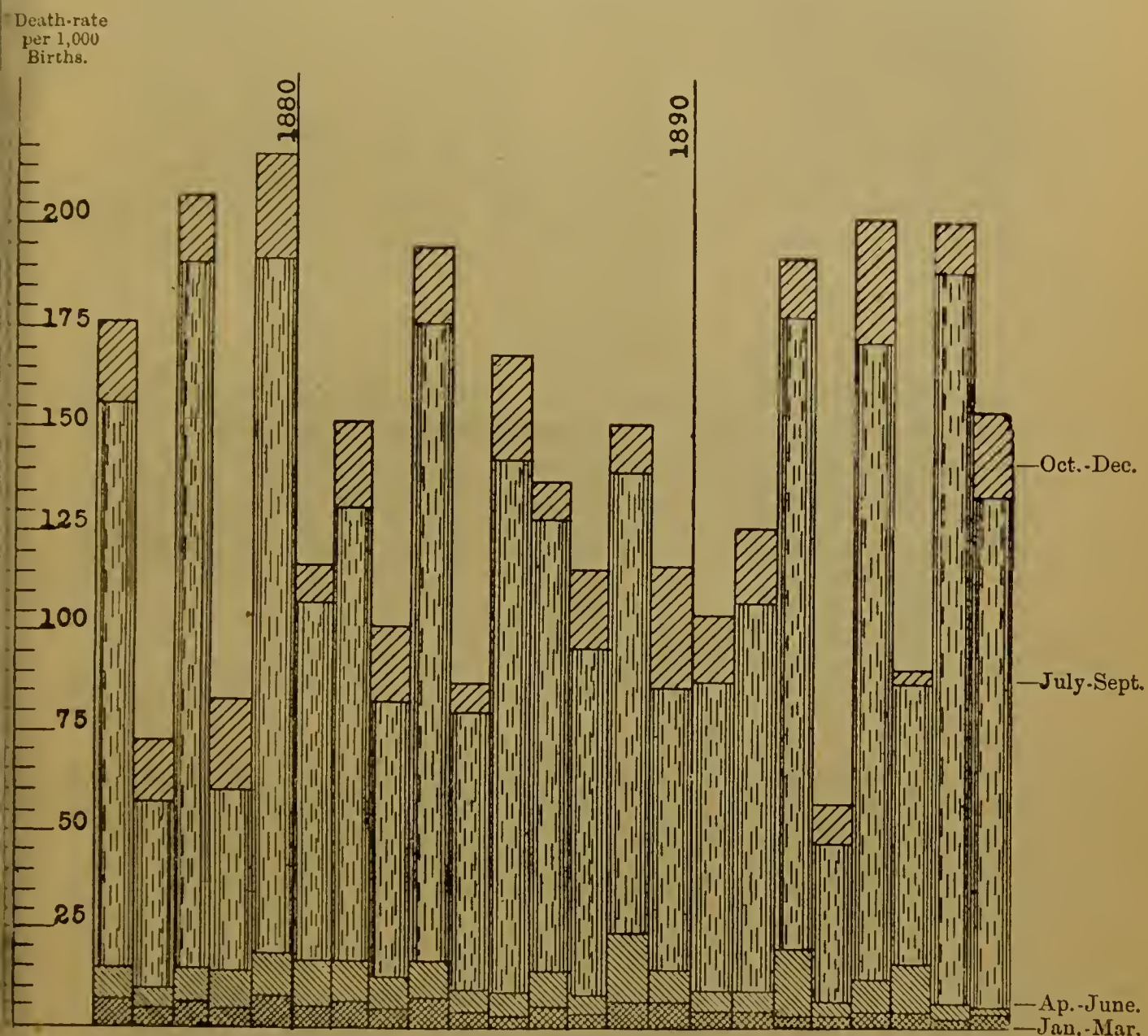

FIG. 22.—LEEDS (1876-98).

Population estimated 1876=291,580.
          ,,   ,,   1898=416,618.

moisture. Houses built on the sandstone are of course drier than those on the clay, but the alluvium itself holds a good deal of water. There are some very steep gradients as we ascend from the river-bed to the various rock strata, but the main sewer through the city has a very little fall indeed. The neighbourhoods of the rivers and the becks have suffered disproportionately to their population from

diarrhœa, but naturally they are not the districts inhabited by the cleanliest of the town people."

Conservancy System.—In 1898 the proportion of houses in the town with water-closets was 48·0, with trough water-closets 23·6, with middens 0·6, and with pails 0·7 per cent.

Course of Diarrhœa.—The average annual death-rate, 1882-98, was 34·3, in the third quarter 107·0, per 1,000 births. The mortality in the lowest (first) forms 4 per cent. of that in the highest (third) quarter of the year. For the first quarter it occupies the seventh, for the second the sixteenth, for the third the twenty-third, and for the fourth quarter the fifteenth, place among the towns in Table C.

The diarrhœa is chiefly of the epidemic type. The town has remained fairly stationary as regards the prevalence of diarrhœa.

Liverpool.

Physiography.—Its outer part, where there are comparatively few houses, is on boulder clay. The greater part is on sandstone, varying greatly in porosity, the softer variety being quite, and the hard only partially, porous. Most of the city is on the softer variety. The residential part is on the pebble-beds of the new red sandstone, also very porous.

Conservancy System.—The w.c. system is now exclusively in use, all the old middens having been converted.

Course of Diarrhœa.—The average annual death-rate, 1882-98, was 34·8, in the third quarter 102, per 1,000 births. The mortality in the lowest (first) forms 7 per cent. of that in the highest (third) quarter of the year. For the first quarter it occupies the eighteenth, for the second the twenty-fourth, for the third the twenty-first, and for the fourth quarter the nineteenth, place among the thirty-one towns in Table C.

The diagram shows no improvement in the incidence of fatal diarrhœa, even if allowance be made for recent hot and dry summers. There is deterioration, particularly in regard to epidemic diarrhœa.

Sheffield.

Physiography.—The middle and lower coal-measures and the millstone grit come to the surface in Sheffield. The populous area in the city is on the coal-measures, which consist of sandstones and shales in narrow beds. The shales near the surface are broken down, and form an almost perfect clay. In many parts the sandstones are also covered with a more or less impervious clay. Sand-
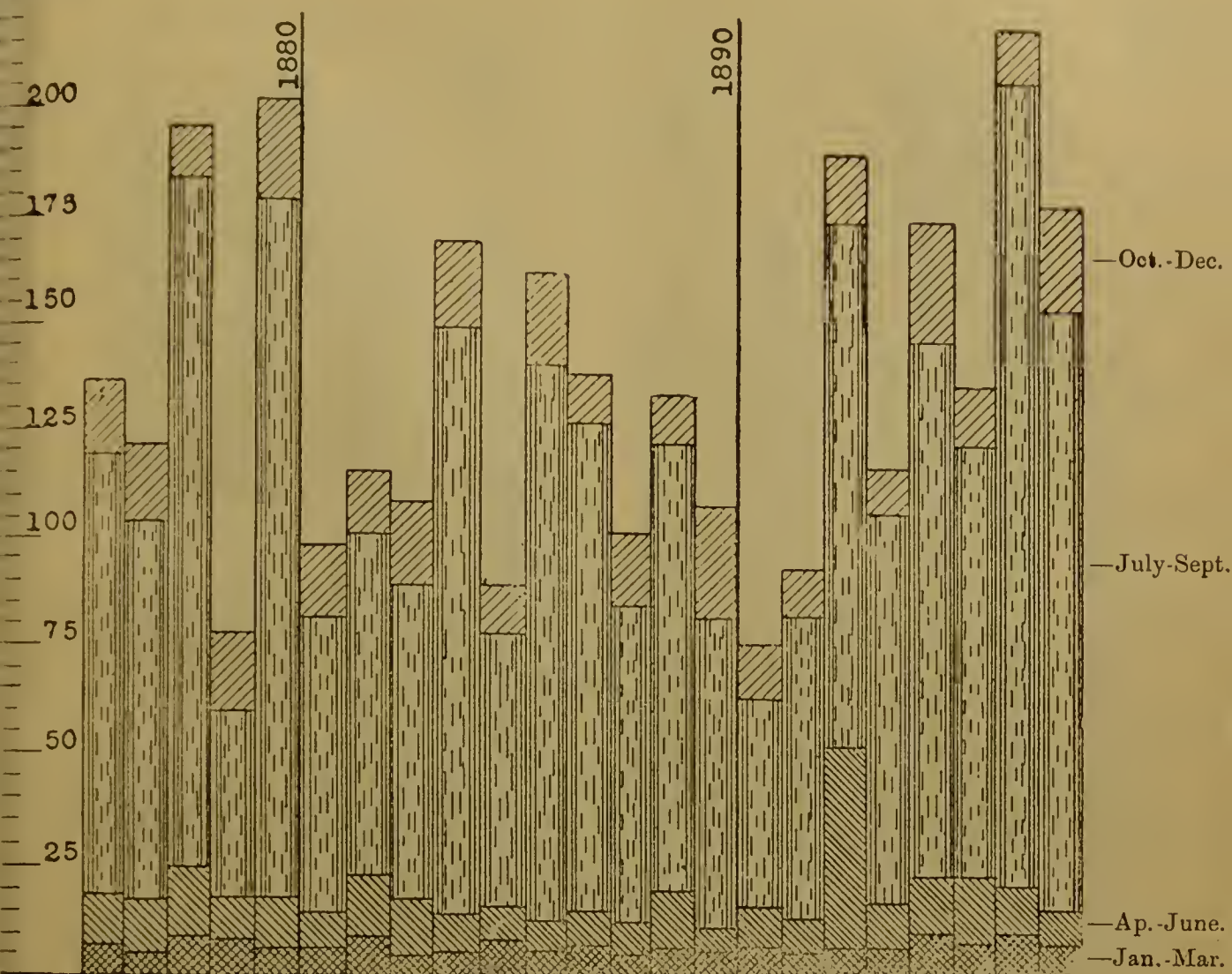
FIG. 23.—LIVERPOOL (1876-98).

Population estimated 1876=521,544.
              „   „   1898=633,645.

stone only comes to the surface in small areas.   Thus the surface is
almost entirely impervious.   The gradients in the city are decidedly
steep.—*Letter from Dr. Robertson, M.O.H.*

Conservancy System. — About 20,000 middens, 5,000 to 6,000
w.c.'s.   A gradual conversion of middens to w.c.'s is in progress.

Course of Diarrhœa.—The average annual death-rate, 1882-98,
was 35·6, in the third quarter 116, per 1,000 births.   The mortality
in the lowest forms only 4 per cent. of that in the highest quarter
of the year.   For the first quarter it occupies the tenth, for the
second the eighth, for the third the twenty-eighth, and for the
fourth quarter the tenth, position among the thirty-one towns in
Table C.   Thus it has, as will be seen better in the diagram (page 60),
but little præ-epidemic and post-epidemic diarrhœa.   The chart
shows no improvement in recent years, but some deterioration.
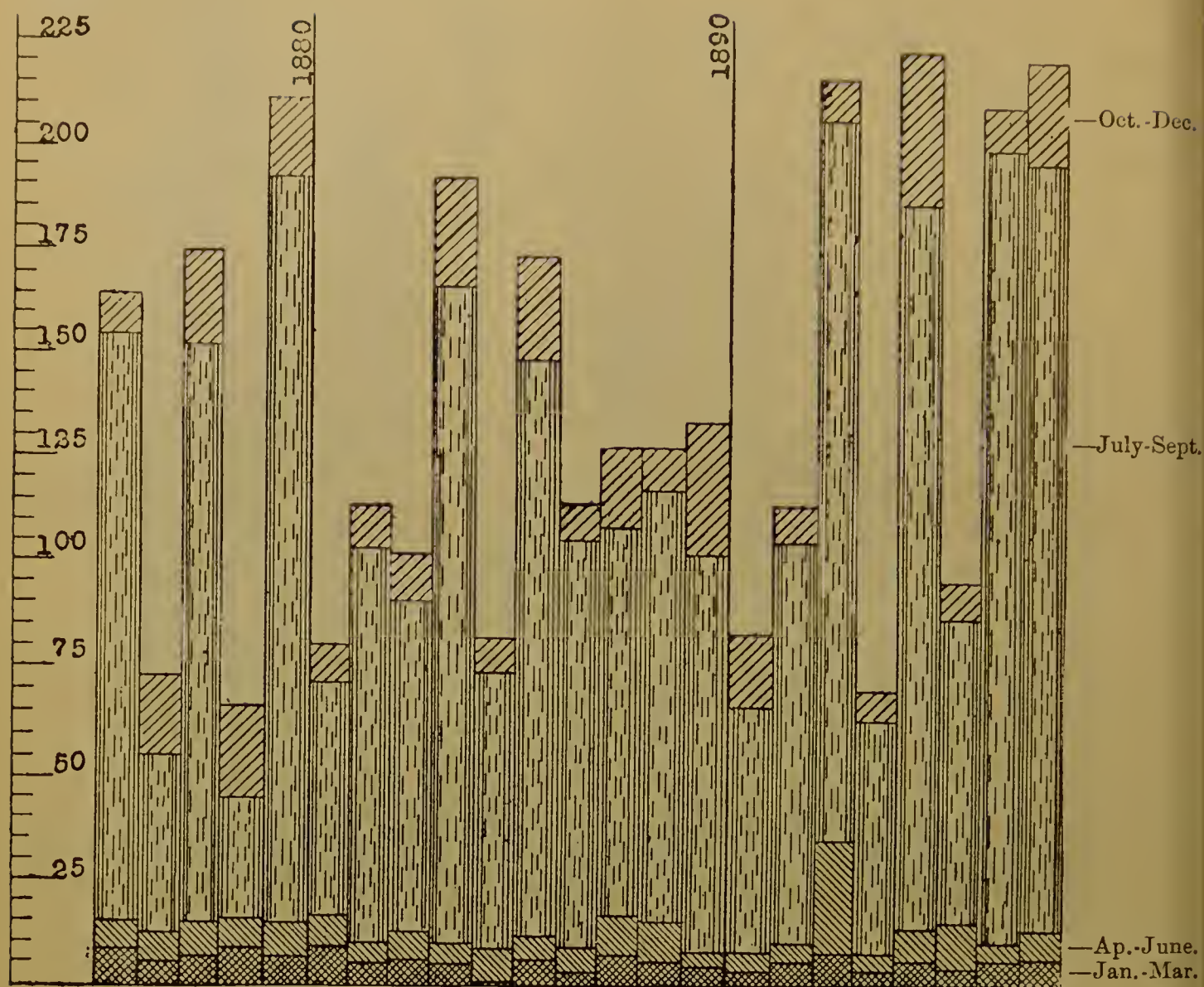
Death-rate
per 1,000
Births.

Fig. 24.—Sheffield (1876-98).

Population estimated 1876=274,914.
     ,,   ,,   1898=356,478.

Wolverhampton.

Conservancy System. — Not many privies; about 14,000 pail-closets and 3,000 water or slop-water closets.

Course of Diarrhœa.—The average annual death-rate, 1882-98, was 37·4, in the third quarter 112, per 1,000 births. The mortality in the lowest (first) forms 7 per cent. of that in the quarter (third) of greatest mortality from diarrhœa. For the first quarter it occupies the twentieth, for the second the fourteenth, for the third the twenty-fourth, and for the fourth quarter the twenty-sixth, place among the thirty-one towns in Table C.

The diagram indicates a considerable deterioration in the condition of Wolverhampton in respect of diarrhœa.
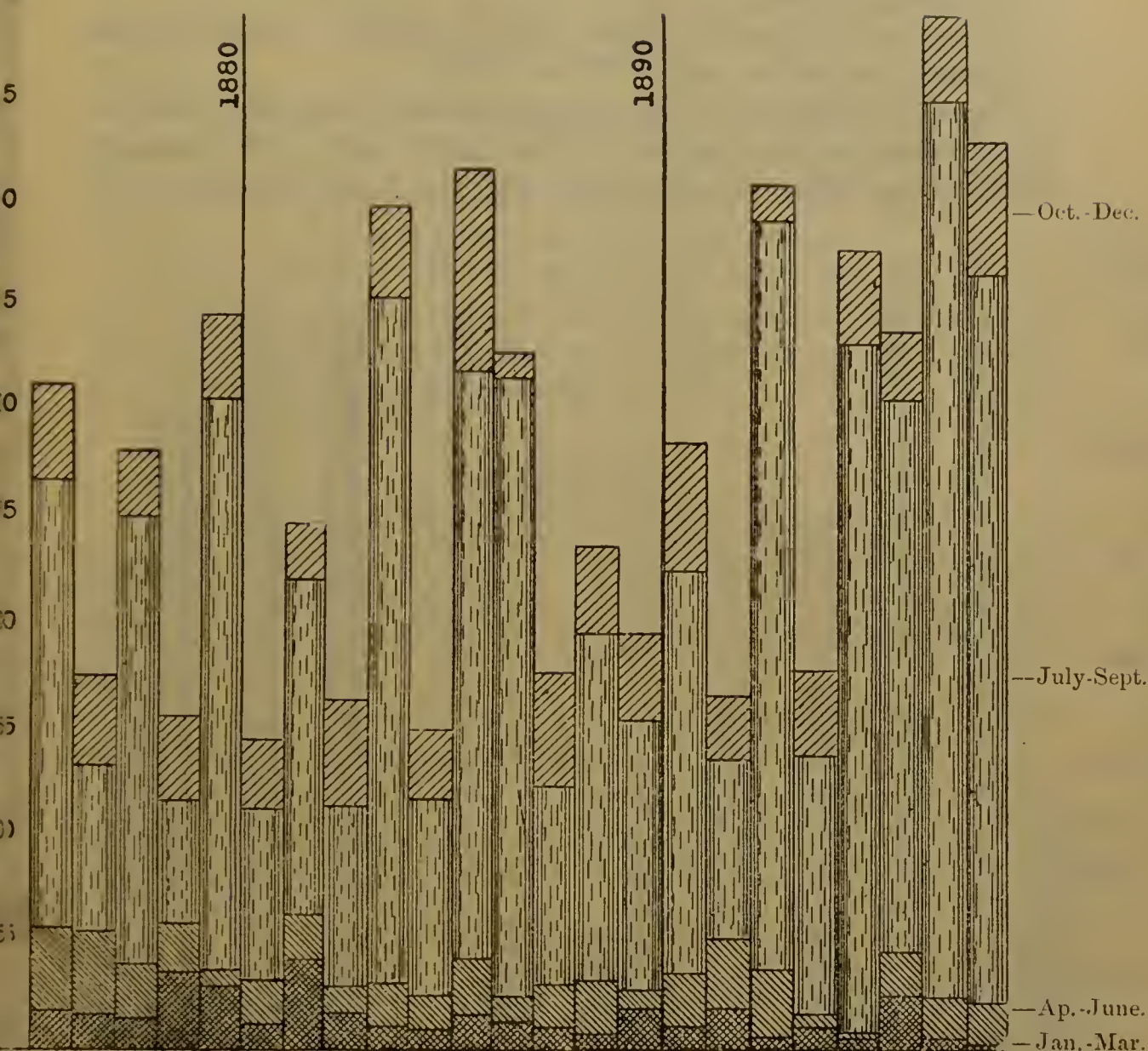
FIG. 25.—WOLVERHAMPTON (1876-98).

Population estimated 1876=72,549.
,,   ,,   1898=88,051,

Hull.

Physiography.—Is a seaport town, standing on·a level plain so low as to render embankment necessary to protect it from inundation. The soil is entirely Humber alluvium, consisting of fine sandy clay, used extensively in making bricks. This deposit is 4 to 10 feet thick, resting on layers of silt, sand, or gravel, the whole of which is incumbent on the chalk formation, which varies from 40 feet to 110 feet from the surface. The area of the borough is flat, and natural drainage would be impossible were it not for the ebb and flow of the tide in the rivers Hull and Humber, by which

a fall of 10 feet to 15 feet is obtained for several hours daily.—
Dr. Mason, M.O.H.

Conservancy System.—About 47,000 middens (mostly small cemented receptacles), and 3,000 to 4,000 w.c.'s.

Course of Diarrhœa.—The average annual death-rate, 1882-98, was 37·9, in the third quarter 118, per 1,000 births. The mortality in the lowest (first) forms 5 per cent. of that in the highest (third)
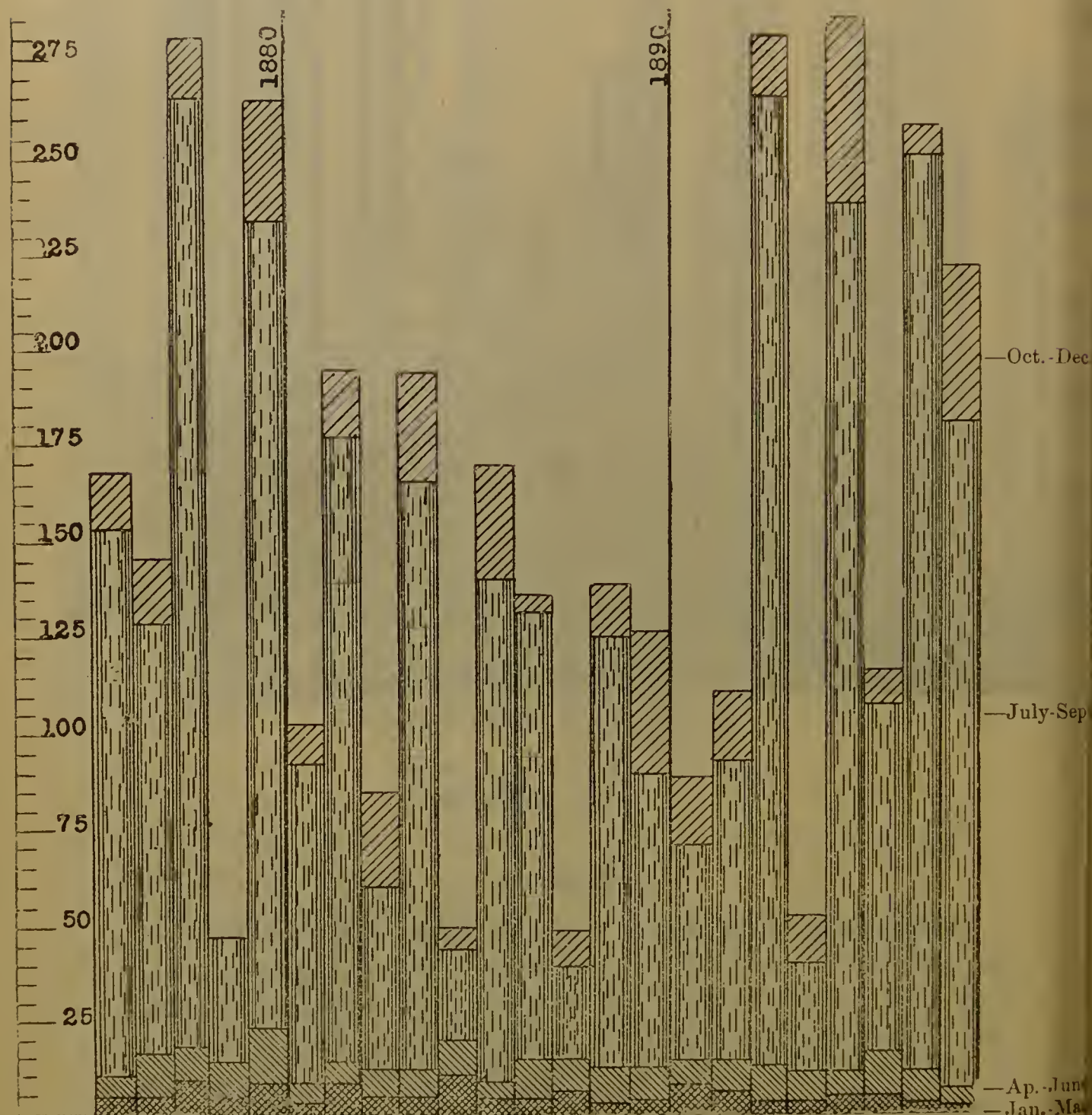
Death-rate
per 1,000
Births.

Fig. 26.—Hull (1876-98).

Population estimated 1876 = 136,933.
„   „   1898 = 229,887.

quarter of the year. For the first quarter it occupies the thirteenth, for the second the tenth, for the third the twenty-ninth, and for the fourth quarter the twenty-fourth, place among the towns in Table C.

The chart shows but little diarrhœa in the first and second quarters of the year. Hull must be included among the places exceptionally sensitive to the causes producing epidemic diarrhœa. There is no evidence of improvement in recent years.

It is interesting to note the smaller amount of diarrhœa (shown also in other towns) in 1881-90 along with climatic conditions on the whole unfavourable to diarrhœa. The excess in recent years is as great as that shown in years before 1881.

Birmingham.

Physiography.—In Dr. A. Hill's annual report for 1893 it is stated that the highest part of Birmingham is 679 feet, and its lowest 261 feet, above sea-level. It is built for the most part on sand or gravel. Thus its soil is porous, and the surface undulating.

Conservancy System.—About 11,000 middens, 33,000 pail-closets, and 38,000 w.c.'s and slop or waste-water closets.

Course of Diarrhœa.—The average annual death-rate, 1882-98, was 38·0, in the third quarter 113, per 1,000 births. The mortality in the lowest (first) forms 7 per cent. of that in the highest (third) quarter of the year. For the first quarter it occupies the twenty-third, for the second the twenty-first, for the third the twenty-sixth, and for the fourth quarter the twenty-third, place among the towns in Table C. The chart (page 64) indicates a fairly stationary condition, neither improvement nor deterioration having occurred to any marked extent. There is excess in præ- and post-epidemic as well as in epidemic diarrhœa.

Salford.

Physiography.—It stands on a level plain, the gradients being slight in nearly all parts. The underlying strata are coal-measures and new red sandstone. The surface drift is of clay and sand. Not more than one-tenth of the houses are on sand, the rest on clay. The clay is in some instances of considerable depth, the bed having been worked to the depth of 50 feet for brick-making. The sand mainly lies over the coal-measures, but sometimes the clay overlies this. There are also pervious pebble-beds throughout the district. —*Dr. Tattersall.*

Conservancy System.—About 13,000 middens, 8,000 pail-closets,
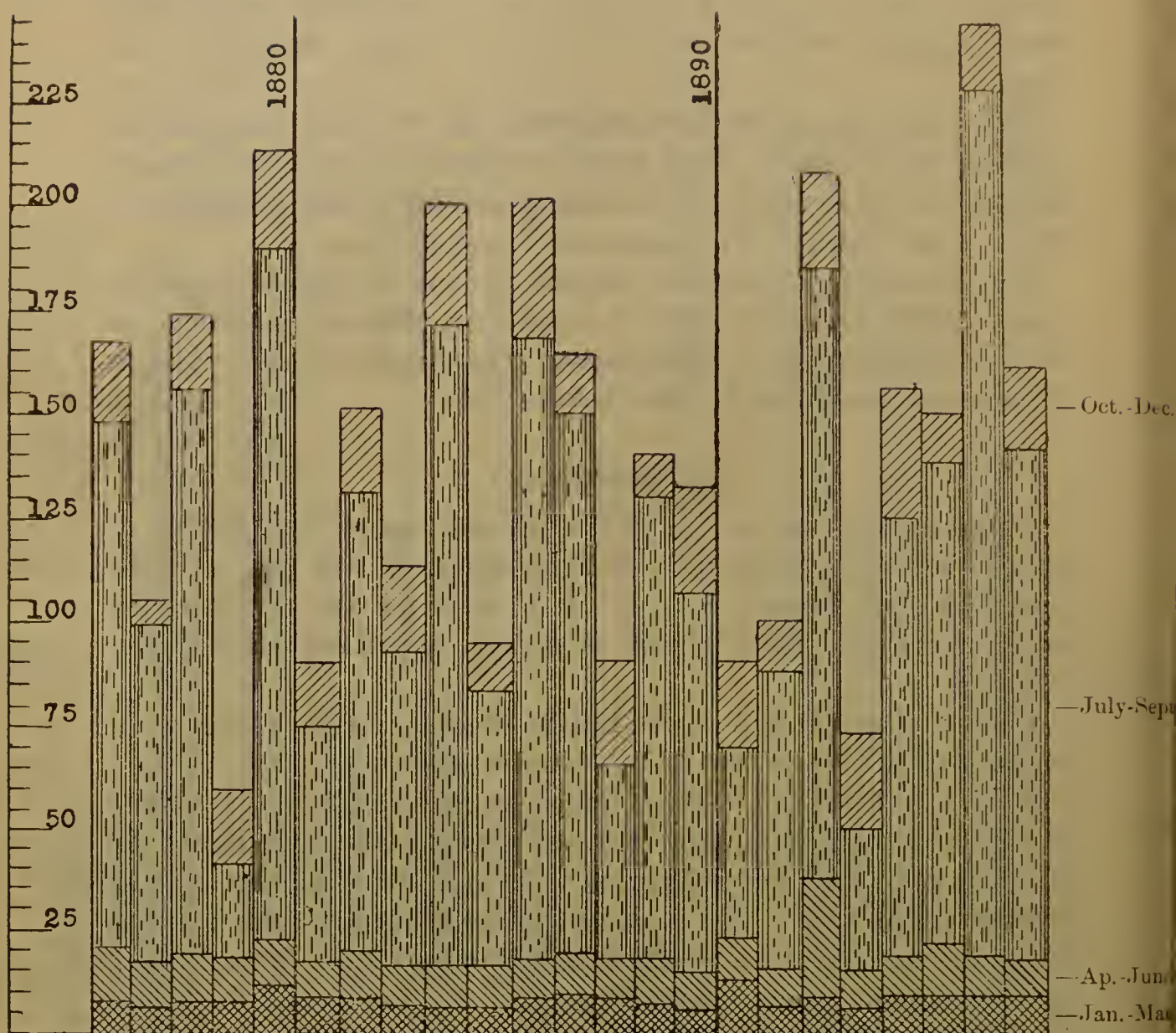
FIG. 27.—BIRMINGHAM (1876-98).

Population estimated 1876 = 371,839.
                    ,,   ,,   1898 = 510,343.

and 5,000 w.c.'s. (Numbers not accurate, but may be taken as an approximate proportion between the three systems.)

Course of Diarrhœa.—The average annual death-rate, 1882-98, was 40·7, in the third quarter 114, per 1,000 births. The mortality in the lowest (first) forms 8 per cent. of that in the highest (third) quarter of the year. For the first quarter it occupies the twenty-fifth, for the second the twenty-ninth, for the third the twenty-seventh, and for the fourth quarter the twenty-seventh place, among the thirty-one towns in Table C.

Salford is the fifth worst of the great towns, and the diagram indicates some deterioration in recent years. Manchester is four-teenth from the bottom of the list in Table C; but it is open to
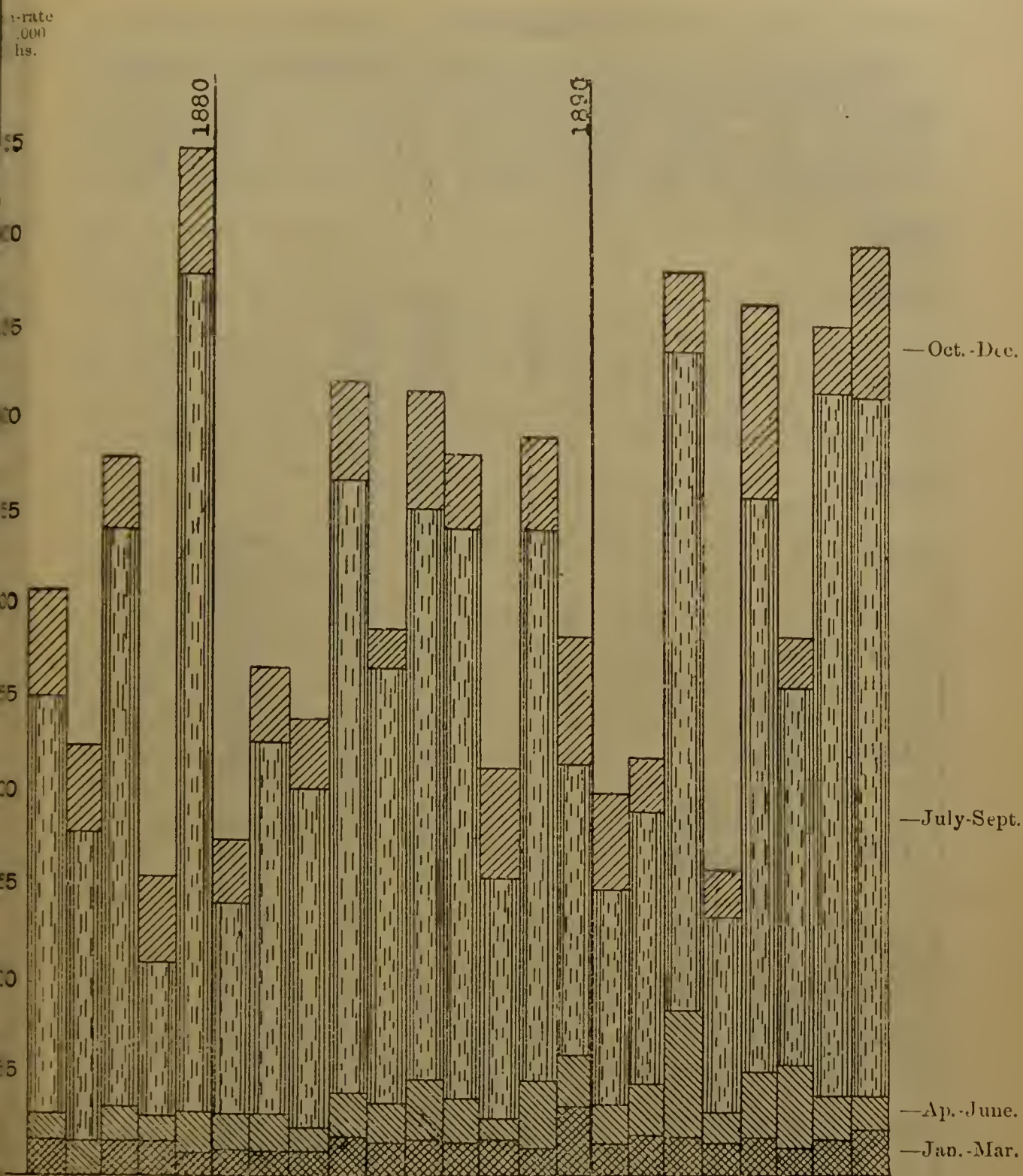
FIG. 28.—SALFORD (1876-98).

Population estimated 1876 = 138,425.

,,   ,,   1898 = 215,702.

surmise that its favourable position is partially caused by the " watering-down " of statistics associated with the inclusion of outlying districts in the city. Salford has, however, always been worse than Manchester re diarrhœa. The density of population in the two cities is practically identical. Salford has a bad record in all four quarters of the year.

Blackburn.

Physiography.—It is situate principally in the valley of the Black-water, and to a much less extent in that of the Darwen, the two rivers joining on the western boundary of the borough. To the north of the Blackwater the land rises, after a few hundred yards, rapidly
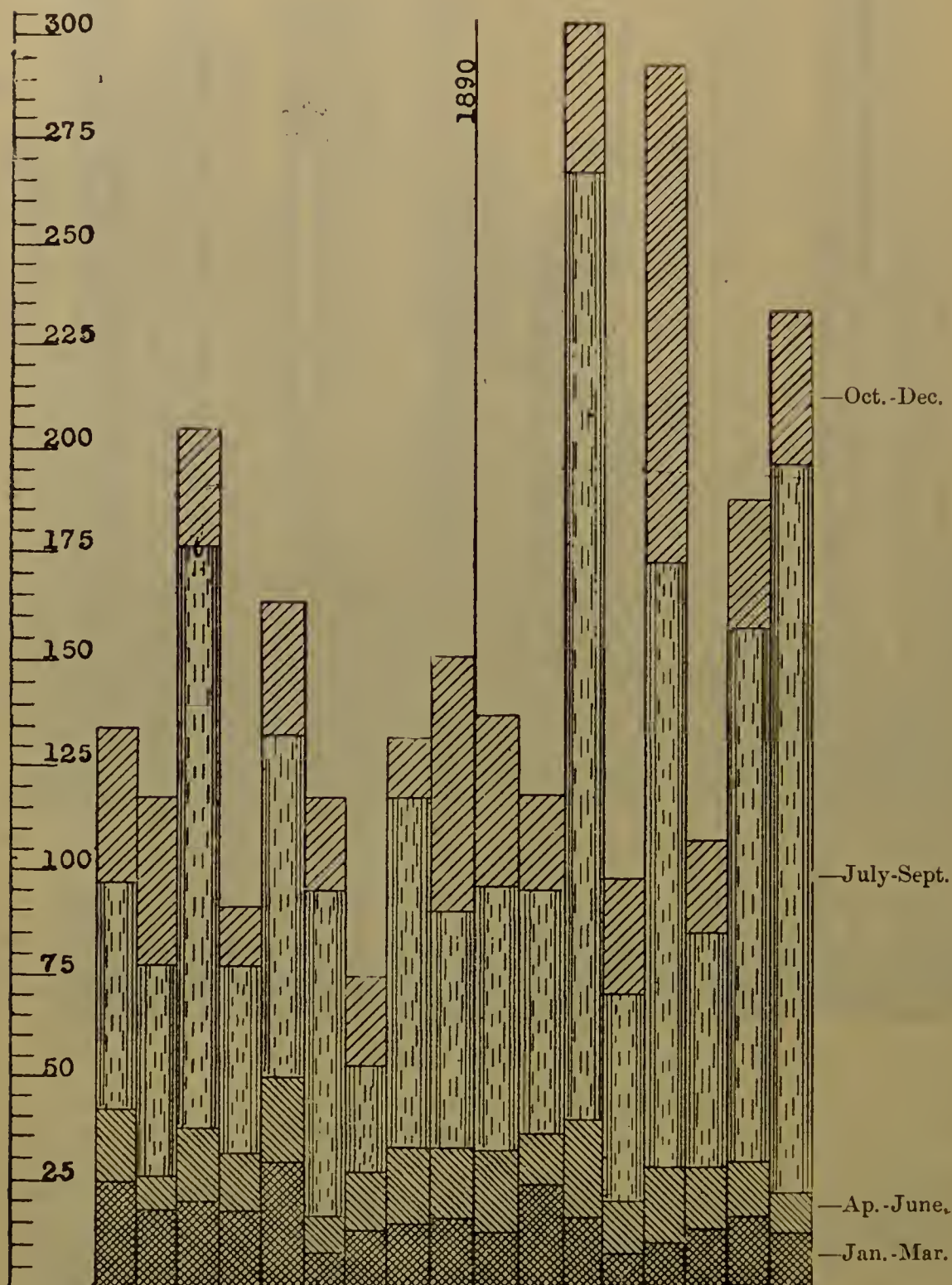
Death-rate
per 1,000
Births.

FIG. 29.—BLACKBURN (1882-98).

Population estimated 1882=106,460.
,,   ,,   1898=133,228.

from 300 to 700 feet high. To the south and west of the Darwen it also rises fairly rapidly from 300 to 600 feet. The land between the two rivers at first has no great inclination, but towards the south-east it rises rapidly to a height of 650 feet. On the north side of the town the gradients are as high in one or two instances as 1 in 7, and 1 in 10 or 12 are not uncommon. On the southern side the steepest slope is 1 in 10. The fall of the valley of the Blackwater is 1 in 138.

The deep strata underlying the town are principally the lower coal-measures, with a narrow strip of alluvium in the valley of the Darwen. Millstone grit (rock and shale) comes to the surface over a considerable area of the northern side of the borough, and to a very small extent on its southern side. The coal-measures are covered with drift beds of clay and sand, and the millstone grit is partly covered. The portion of the borough on millstone grit is principally agricultural land, at least 90 per cent. of the town being on the coal-measures.

The drift beds are principally clay, although there is a considerable area in the centre of the town with a good depth of fine sand. Probably about one-sixth of the town is built upon sand, and five-sixths upon impervious clay or a mixture of clay and gravel. A few houses are built on rock. (The above description is taken almost verbatim from a letter from Dr. Wheatley to the writer.)

Conservancy System.—About 35,000 middens, 10,000 pails, and 10,000 water-closets. Gradual replacement of middens by w.c.'s proceeding.

Course of Diarrhœa.—The average annual death-rate, 1882-98, was 41·3, in the third quarter 89·3, per 1,000 births. The mortality in the lowest (first) forms 18 per cent. of that in the highest (third) quarter of the year. In the first quarter it occupies the thirty-first, in the second the thirtieth, in the third the sixteenth, and in the fourth quarter the thirtieth, place among the towns in Table C.

Although the chief incidence of diarrhœa is in the third quarter, it has also an exceptionally large amount in the other quarters of the year, especially the fourth. In this respect it resembles the Scotch towns, but is much worse than the latter, and than any other town in the first and second quarters, and than any other town, except Preston, in the fourth quarter. The town is deteriorating as regards both endemic and epidemic diarrhœa.

Bolton.

Physiography.—Is eleven miles north-west of Manchester. It lies in the undulating plains of the coal-measures, in the central part of

the Lancashire coal-field, with its south and north boundaries of new red sandstone and millstone grit. The district is deeply overspread with boulder clay and sand. The valley in which Bolton lies is surrounded by hills on three sides, being open to the south, where
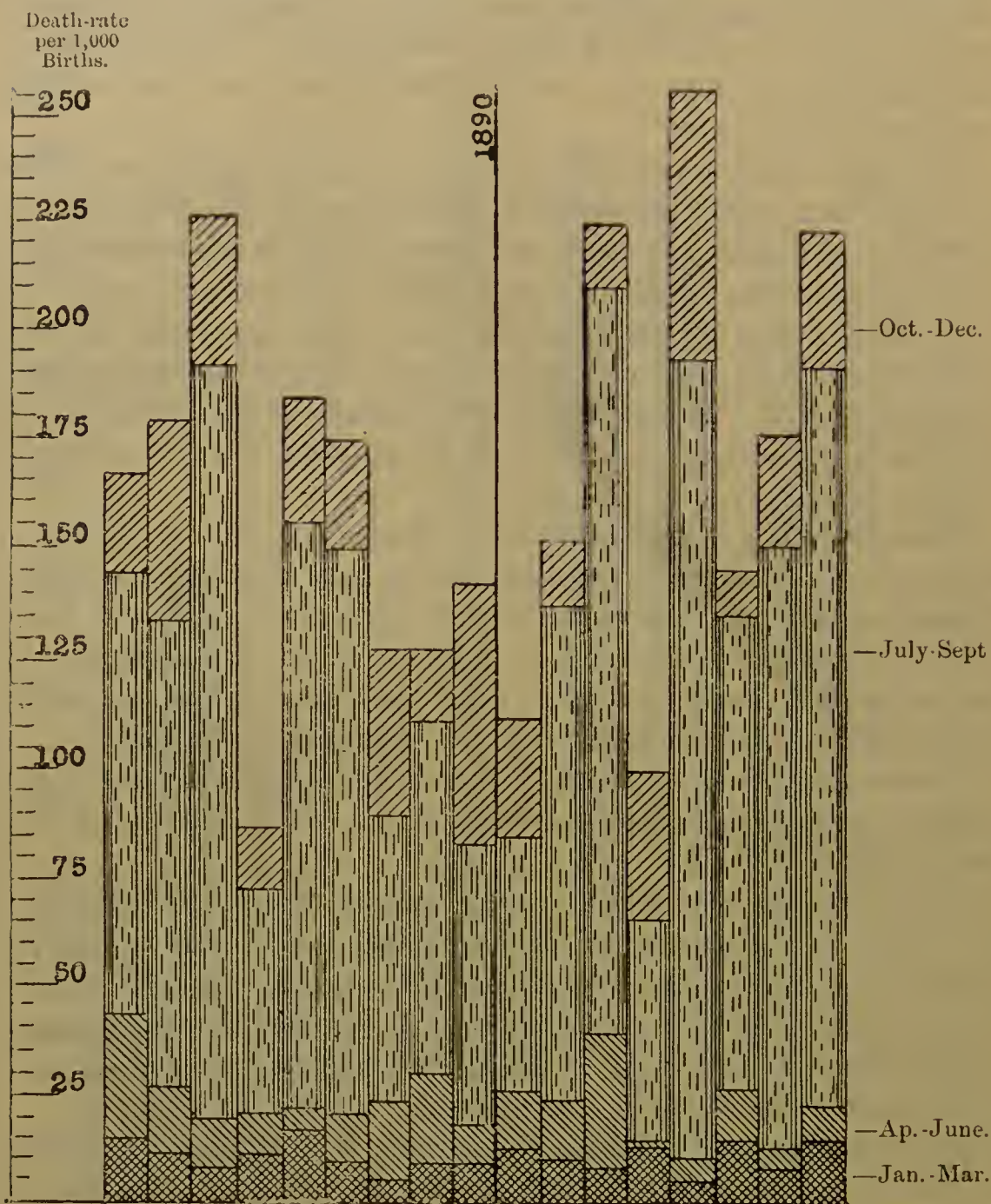
Death-rate
per 1,000
Births.

Fig. 30.—Bolton (1882-98).

Population estimated 1882 = 106,767.
        ,,   ,,   1898 = 122,495.

it slopes gradually towards Manchester. Its elevation varies from 230 to 500 feet above sea-level.—*Report of M.O.H.*, 1896.

Conservancy System.—A gradual conversion to the w.c. system is going on; but there are still in the old borough 12,740 privy-ashpit

closets, and 6,782 pail-closets as well as 4,702 waste-water closets, and 2,295 fresh-water closets.—*Annual Report, Dr. Gould*, 1898.

Course of Diarrhoea.—The average annual death-rate, 1892-98, was 42·0, in the third quarter 112, per 1,000 births. The mortality in the lowest (first) forms 9 per cent. of that in the highest (third) quarter of the year. For the first quarter it occupies the twenty-seventh, for the second the twenty-eighth, for the third the twenty-fourth, and for the fourth the twenty-ninth, place among the thirty-one towns in Table C.

There is, up to the end of 1898, no improvement, the town appearing to be gradually deteriorating in respect of diarrhoea. Note the excess in the fourth quarter, and the fact that diarrhoea is constantly present in larger amount than in most English towns.

Leicester.

Physiography.—Is a midland town, situated in a gentle hollow on the river Soar. Speaking generally, it is upon clay, beneath which lies the new red sandstone; but following the bed of the river for a variable distance on either side, alluvial deposit is found consisting of sand, gravel, etc., of a varying thickness. The greater part of the population is housed on the marshy alluvium, the remainder on boulder clay and on marl and other impervious beds. The subsoil of the borough has been for a long time in a polluted state, and in many localities, according to the late Dr. Tomkins (from whose report for 1887 most of the above information is derived), it is actually sewage-sodden. The direction of the valley is such that the prevailing winds do not sweep along it, but rather across it. Dr. W. E. Buck* describes Leicester as "virtually in a hole with a canalized river dammed up against it by mills and locks." There is on the north-east of the town a brook, which is held up by the river, and which is known to affect wells to a considerable distance.

Conservancy System.—In 1896 about 20,000 w.c.'s, 7,000 pails, and 2,000 middens (probably a larger proportion of w.c.'s in 1898).

Course of Diarrhoea.—The average annual death-rate, 1882-98, was 48·7, in the third quarter 163·6, per 1,000 births. The mortality in the lowest (first) forms only 2 per cent. of that in the highest (third) quarter of the year. For the first quarter it occupies the second, for the second the twenty-fifth, for the third the thirtieth, and for the fourth quarter the eighth, place among the thirty-one towns on page 9.

The diagram for Leicester shows a marked contrast to those for Preston and Bolton in the fact that there is very little early præ-

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* *Trans. San. Inst.*, vol. vii., 1885.
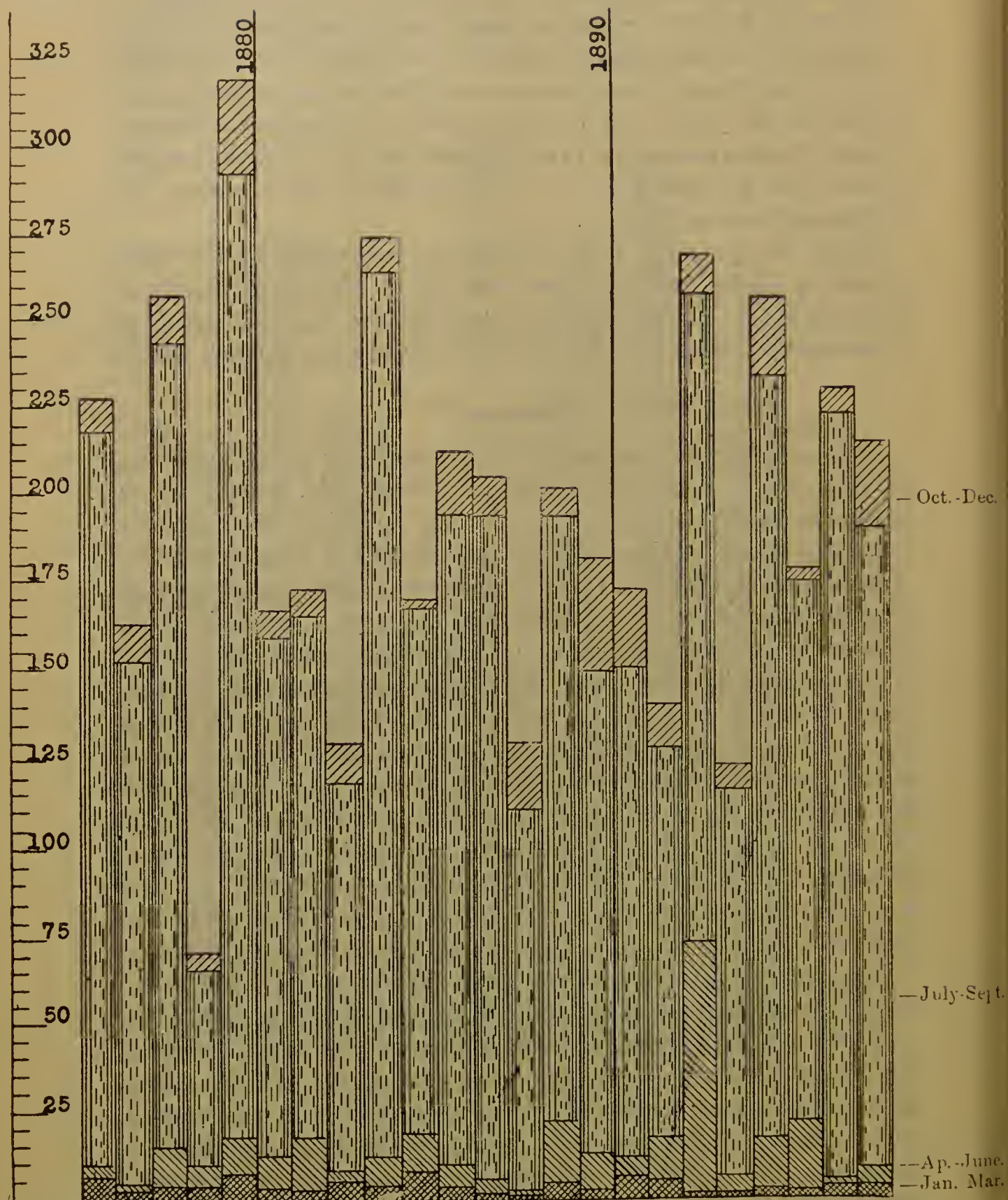
Death-rate
per 1,000
Births.

FIG. 31.—LEICESTER (1876-98).

Population estimated 1876=113,581.
    „   „   1898=208,662.

epidemic or post-epidemic diarrhœa. Nearly all the diarrhœa is of
the epidemic type, occurring in the third quarter of the year, and

to some extent in its second quarter. The second quarter of 1893, as in many other towns, was an illustration of an epidemic commencing unusually early, under the influence of exceptional heat. Whatever may be the cause or causes of epidemic diarrhœa, Leicester responds more rapidly than most other towns to their operation.

There is a tendency to improvement. Probably the main sewerage scheme and the rapid adoption of w.c.'s has much to do with this.

Preston.

Physiography.—Dr. Pilkington, M.O.H., informs me that the soil underlying the town is chiefly sand and marl, with some made ground and a small amount of alluvial deposit. The gradients do not appear to be great.

From information derived from the surface or drift map of the Geological Survey, it appears that about half the town is built on upper boulder clay, the other half on glacial gravel. Dr. W. E. Buck* states that the clay has running in it springs of sand which have an abundant supply of water, and that the lower part of the town is on a black loamy soil, beneath which is a marshy and peaty subsoil, with subsoil water from 10 to 15 feet from the surface, *i.e.*, about the same, according to him, as at Leicester.

Conservancy System.—In 1894 one-fourth of the houses had w.c.'s, the remainder midden-privies. In 1899 Dr. Pilkington informs me there are about 5,600 privies, 12,074 w.c.'s and ashpails, and 400 dry ashpits.

Course of Diarrhœa.—The average annual death-rate, 1882-98, was 60·4, in the third quarter 173, per 1,000 births. The mortality in the lowest (first) forms 8 per cent. of that in the highest (third) quarter of the year. For the first quarter it occupies the thirtieth, for the second the thirty-first, for the third the thirty-first, and for the fourth the thirty-first, place among the thirty-one towns in Table C.

This town occupies a supreme position amongst the great towns in incidence of fatal diarrhœa, having taken the place formerly occupied by Leicester. The excess of diarrhœa is equally great in every quarter of the year.

The large excess in the second quarter of 1893 will be noticed, associated with the exceptional heat and dryness of the second quarter of that year; and in connection with this it is interesting to note that in the Southern States of America diarrhœa is called the "summer complaint" or "April-and-May disease."

The diagram indicates a distinct tendency towards improvement,

* *Trans. San. Inst.*, vol. vii., 1885.
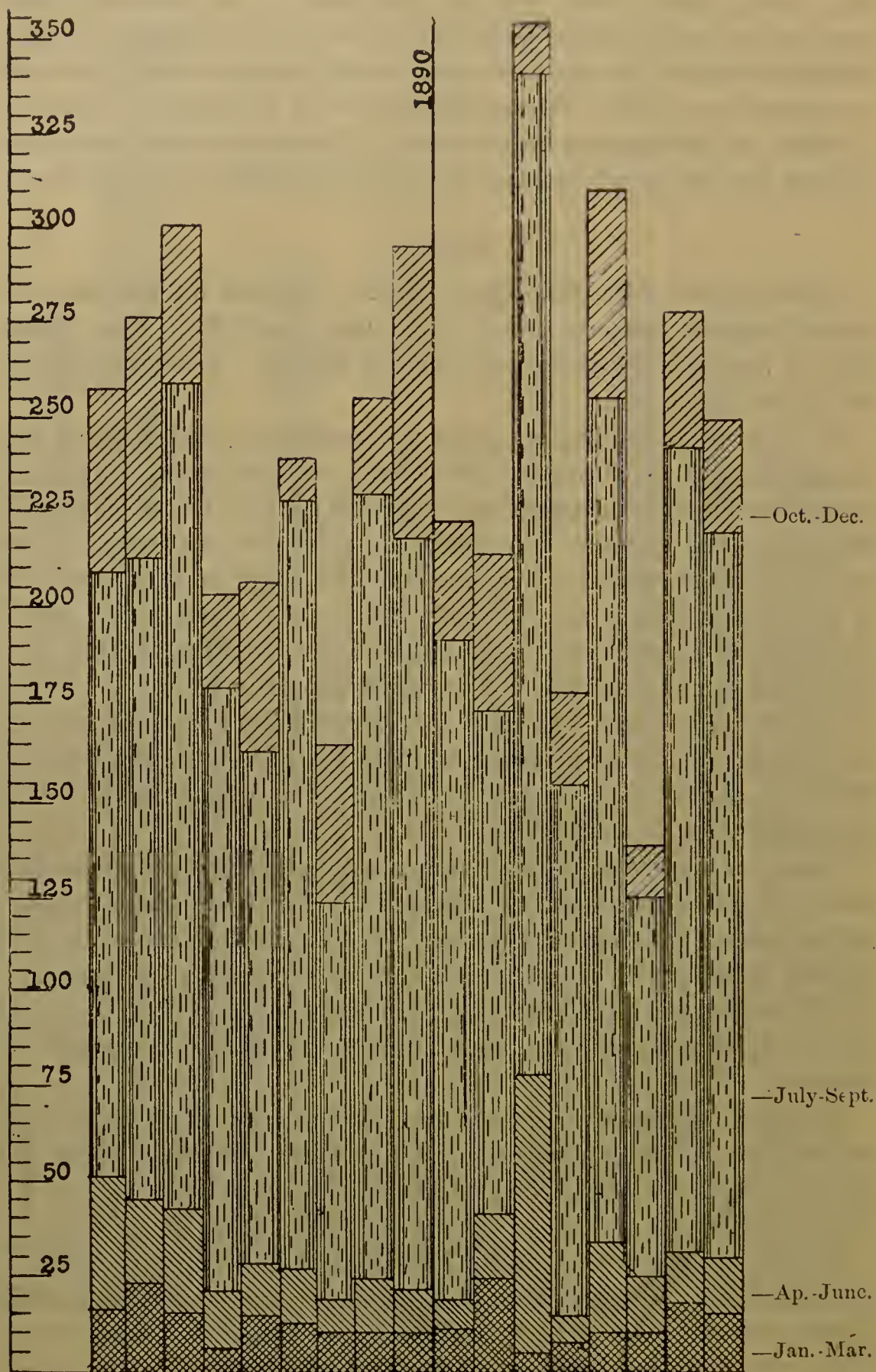
Death-rate
per 1,000
Births.

FIG. 32.—PRESTON (1882-98).

Population estimated 1882= 97,656.
,,   ,,   1898=116,356.

notwithstanding the fact that the climatic character of recent years has favoured a heavy diarrhœal mortality. Towns with a high diarrhœal mortality can more easily show an improvement than other towns which never suffered to the same excessive extent from diarrhœa. Some of this improvement is probably caused by the gradual conversion of privies into w.c.'s.

DISCUSSION.

The PRESIDENT expressed a wish that his address might be discussed.

Dr. GWYNN proposed that the thanks of the Society be accorded to the President for his address. He anticipated that the address would become a classic in medical literature. He noticed that 75 per cent. of the deaths were those of infants, and he would like to ask the President whether he had any statistics as to the prevalence of diarrhœa among illegitimate children. During last summer there were three deaths of illegitimate infants from diarrhœa in one house in his district. Each of the women receiving these children had charge of only one child, and so escaped registration. The coroner did not think it necessary to hold an inquest. It was an easy matter to feed such children improperly, induce diarrhœa, and thus dispose of them in an apparently legitimate manner.

Dr. F. PARSONS, in seconding the vote of thanks, remarked that the President had placed his facts before them in a new light, and that the use of the deaths-to-births ratio was most interesting. He was much gratified to hear the President's appreciation of Dr. Ballard, whose work had stood the test of time, and whose reports of twenty-five years ago were almost up to the present date. Earth temperatures at a depth of 4 feet were valuable as a measure of the cumulative effect of the sun's heat. The variations in such thermometers followed those of a thermometer above ground at an interval of about three or four days. On an average twenty-four hours were required for the sun's heat to penetrate to a depth of 1 foot, the actual time varying somewhat with different soils. Referring to the difference in diarrhœa death-rates in Yorkshire and Lancashire, Dr. Parsons said the rainfall in Yorkshire was much larger than in Lancashire. The towns themselves were very similar in many respects. They were all on coal-seams, and the women for the most part were workers, but the diarrhœa was greater in Lancashire than in Yorkshire, owing perhaps more to the social characteristics of the populations than anything else. He agreed with Dr. Newsholme that they should regard dirt as an important factor in the propagation of diarrhœa. Dr. Parsons described in detail the common practice of depositing in the course of removal the contents of middens on the surface of yards or in the streets. The filth left on the ground when dry became dust, was deposited on food or was inhaled, and so taken into the system. The importance of surface cleanliness could not be emphasized too much, and he would suggest that in seaport towns sea-water could be used for the purpose with advantage.

At the conclusion of his remarks, Dr. PARSONS put the motion to the meeting, and it was carried unanimously.

Dr. E. F. WILLOUGHBY desired to know what statistical evidence Dr. Newsholme possessed in support of his theory that the low mortality in Whitechapel was due to the excessive proportion of Jewish infants. Some time ago he (Dr. Willoughby) had been consulted by the Chief Rabbi on the diarrhœa mortality of infants, but he was unable to arrive at any conclusion in the

absence of proper statistical data. In reference to the emptying of cesspools, he could not understand why the pneumatic system was not adopted.

Dr. Sykes asked whether gastro-enteric catarrh, etc., were included in the statistics mentioned in the paper. (The President replied that catarrh was included.) The following interesting paragraph at the end of the address: " When we remember how common are secondary and tertiary cases of enteric fever in houses where unskilled nurses are employed to nurse the first patient, it is not surprising that the same should hold good for diarrhœa," he thought should be elaborated, because it emphasized the fact that diarrhœa was a personally infectious disease, just as enteric fever. He was of opinion that definite action ought to be taken for the prevention of personal infection in addition to those measures of municipal administration which the President had indicated.

Dr. Seaton urged that all privy middens should be abolished. The question of nomenclature and classification of the diarrhœal diseases and deaths was of vital importance as dealing with the subject of the address. This subject of classification of diarrhœa deaths was at the present time under the consideration of a Committee of the Royal College of Physicians. He had no doubt the President had exercised a great deal of supervision over the tables appended to his paper, and eliminated all kinds of error, but they had to recognise that there was any amount of latitude for error in the way in which these cases were registered by the registrar of deaths.

Dr. Groves said there were two forms of diarrhœa registered : one which arose from improper feeding, especially among children ; and another, what they might call " epidemic " diarrhœa, found among adults and children, and often attacking all the members of a house. This latter form lasted three or four days, and was characterized by diarrhœa and (sometimes) sickness. He thought medical officers of health should do more with reference to the feeding of infants. On the question of scavenging, he said it was the medical officer's duty to see that the removal of filth was carried on in a proper way. In his district the pneumatic system of emptying cesspools had been adopted, and was a fruitful source of complaint. The stench from it was unbearable. Moreover, the exhaust could not deal with the sediment at the bottom of the pit, which the people insisted on being removed.

Dr. Murphy desired to express his warm appreciation of the President's excellent work, and to say how greatly it would help those who were studying the subject. With regard to the London diarrhœa death-rate, he had observed that its incidence on the several districts was much governed by the social condition of the inhabitants. It might be hoped, by degrees, that the social condition of the poorer and more ignorant classes would be improved, and that from that cause alone there might be a lessening of diarrhœa ; but apart from such possible means of lessening the death-rate, the President had suggested that important measures could be at once adopted with this object. A great deal could be done by cleansing the towns and dwellings. With respect, for instance, to the collection of house refuse, a good deal of difficulty had been experienced in getting a weekly collection instituted in London. The matter had not formerly been regarded from a health point of view, but merely from that of convenience. He was glad to say, however, that the weekly collection had extended, and taken very firm root, and he hoped that, after the weekly collection had become well established, an effort would be made to shorten the period from a week to twenty-four hours. Reference had been made to the necessity for strict supervision of the milk supply. It was well known that

milk, even from good dairies, often contained more or less excremental matter. The position of the udder and the absence of hand cleanliness on the part of the milkers, etc., caused much pollution, and it was very important that some steps should be taken to remove such impurities from milk before supplying it to the consumer. He had seen what was done in Berlin, Copen-hagen, and Christiania; they were far ahead of us. The milk supplied by one company in Berlin was filtered very carefully through sand, and great pre-cautions were taken to supply it in a clean and wholesome condition.

Dr. ALLAN urged that inquiries should be made into all cases of diarrhoea. He had made such inquiries during the last few years, and was astonished at the number of deaths erroneously certified as due to diarrhoea, and, on the other hand, he had discovered that a considerable number of deaths of children certified as due to marasmus, etc., were really due to diarrhoea. Far more attention ought to be given to securing cleanliness in houses and back yards than they found at present. On the whole, the streets were more efficiently cleansed than formerly; now more domestic cleanliness was needed. Dr. Groves had sug-gested that medical officers should speak to the people with whom they came into contact, but more might be done by women health visitors. Much had already been accomplished by such officers in Huddersfield and Birmingham.

The PRESIDENT, in reply, said he was much obliged to the Society for the way they had received his address and for the vote of thanks they had accorded him. He heartily agreed with Drs. Groves and Allan as to the importance of education, but he preferred the system of the Brighton Women's Health Society, which employed ladies to attend mothers' meeetings and explain simple health matters. In this way much good had been accomplished more rapidly than by visits to individual houses. He agreed with Dr. Murphy that diarrhoea deaths in London had adjusted themselves almost solely according to social conditions, but when comparing one town with another a geographical and meteorological classifica-tion touched more closely the real causation of the disease. Dr. Seaton had spoken of the question of classification. For his part, he felt sure that statistics on the whole did tell them approximately the *relative* truth for towns when the same year was taken, although, of course, it was very desirable that a proper classification of diarrhoea deaths should be made. With regard to the infectious character of diarrhoea and many other points, they were very im-portant, and should be carefully worked out; but he could not go into them all, and that part of the subject he would have to leave to somebody else. His remarks as to the Jews, Dr. Willoughby would find, were in the nature of a question, and not stated as facts. He did not believe there was any question of race, but was it not possible that Jewish children were more commonly suckled than the children of Gentiles? Dr. Parsons thought that the fact of the mortality being higher in Lancashire than in Yorkshire towns was an argument against the suggestion that rainfall was a chief factor in relation to prevalence of diarrhoea, but Dr. Parsons would find that the Yorkshire towns to which he (Dr. Newsholme) referred, i.e., Huddersfield and Halifax, were really Lancashire towns so far as rainfall was concerned. He had statistics illustrating the great excess of diarrhoea mortality among illegitimate infants. It was three or four times as high as that among legitimate children. In conclusion, he hoped the various Branches would consider the subject, so that collective results might be obtained from all parts of the country.